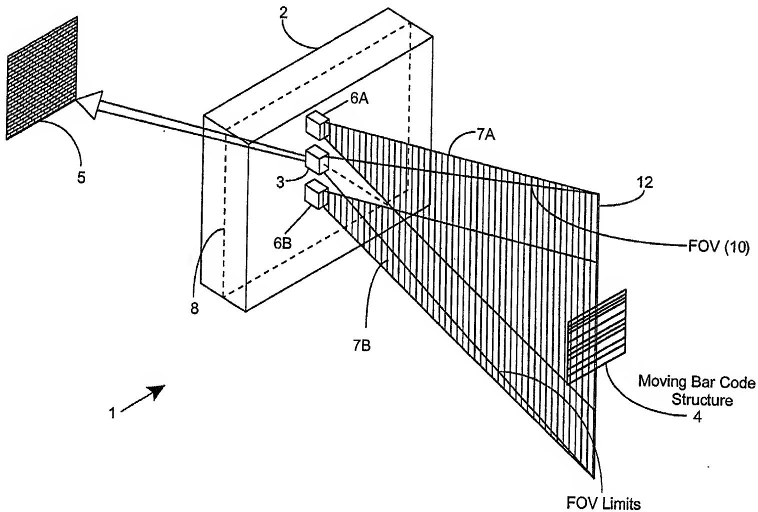

2
6A
7A
5
3
12
6B
FOV (10)
8
7B
Moving Bar Code
Structure
4
1
FOV Limits

FIG. 1A

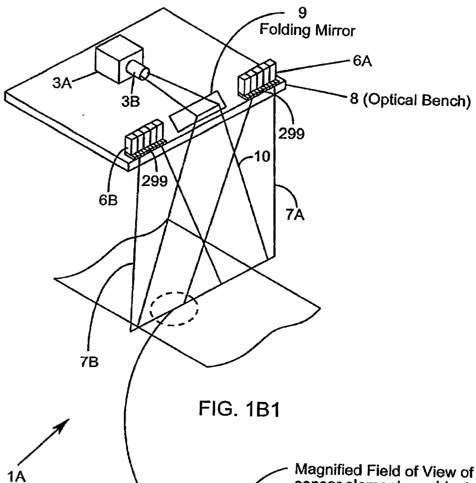


FIG. 1B1

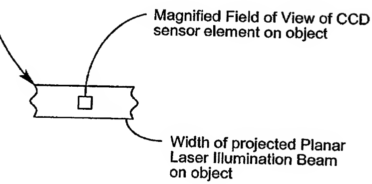


FIG. 1B3

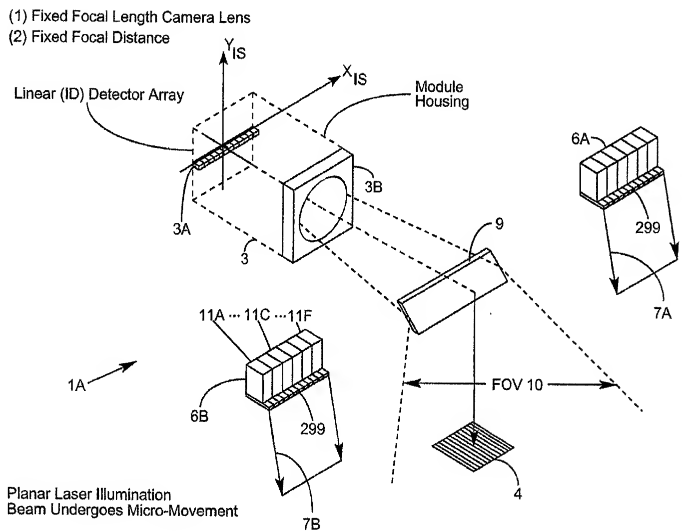

(1) Fixed Focal Length Camera Lens
(2) Fixed Focal Distance
Y_{IS}
X_{IS}
Linear (ID) Detector Array
Module Housing
6A
3B
3A
9
299
3
7A
11A ··· 11C ··· 11F
1A
FOV 10
6B
299
4
Planar Laser Illumination
Beam Undergoes Micro-Movement
7B

FIG. 1B2

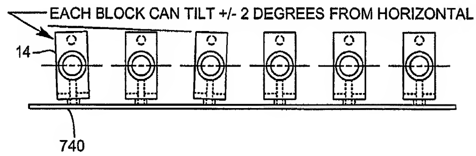


FIG. 1B4

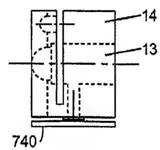


FIG. 1B5

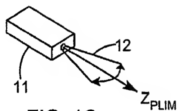


FIG. 1C

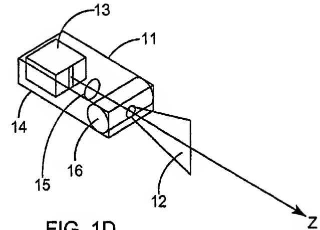


FIG. 1D

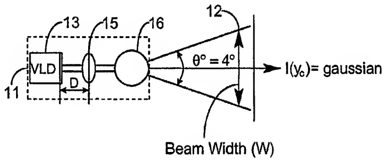


FIG. 1E1

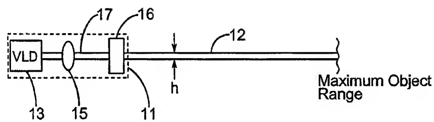


FIG. 1E2

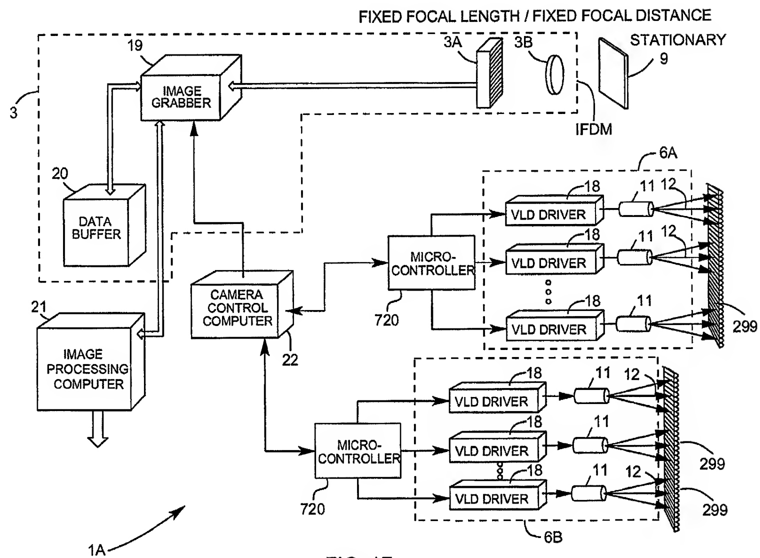

FIXED FOCAL LENGTH / FIXED FOCAL DISTANCE
STATIONARY
9
3A
3B
IFDM
3
19
IMAGE GRABBER
20
DATA BUFFER
21
IMAGE PROCESSING COMPUTER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
720
6A
18
VLD DRIVER
11
12
299
6B
1A

FIG. 1F

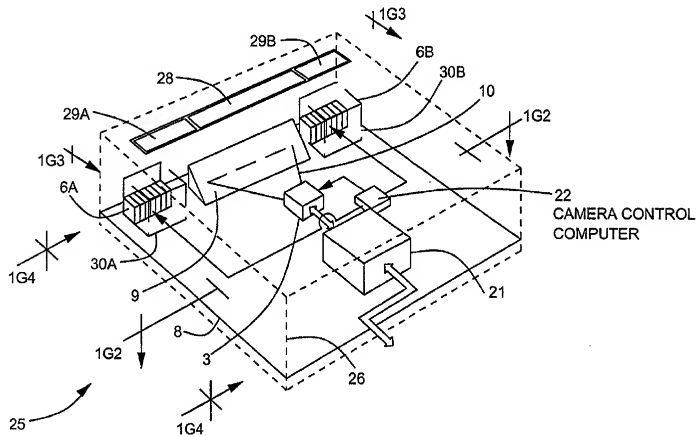

1G3
29B
6B
28
30B
10
29A
1G2
1G3
6A
22
CAMERA CONTROL
COMPUTER
1G4
30A
9
21
8
1G2
3
26
25
1G4

FIG. 1G1

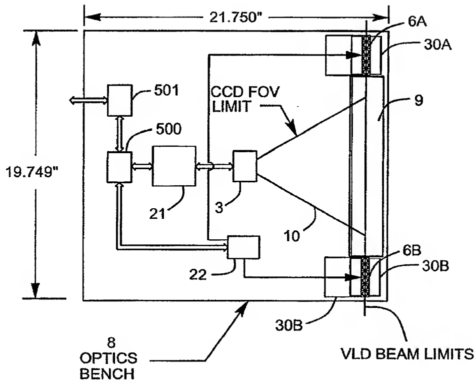

21.750"
6A
30A
501
CCD FOV
LIMIT
9
500
19.749"
21
3
10
6B
30B
22
30B
8
OPTICS
BENCH
VLD BEAM LIMITS

FIG. 1G2

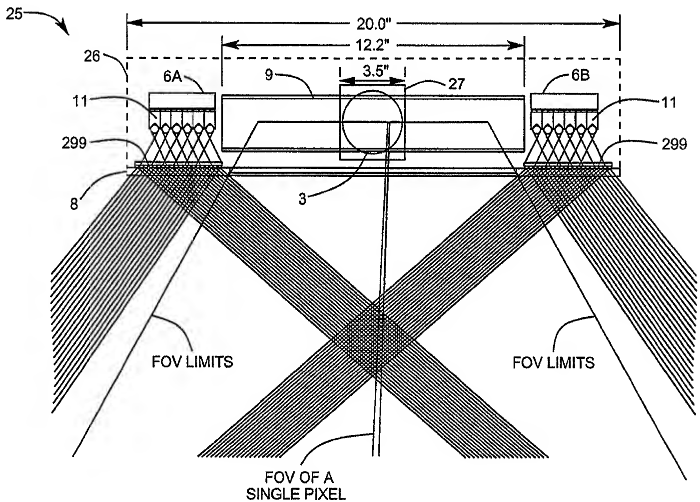
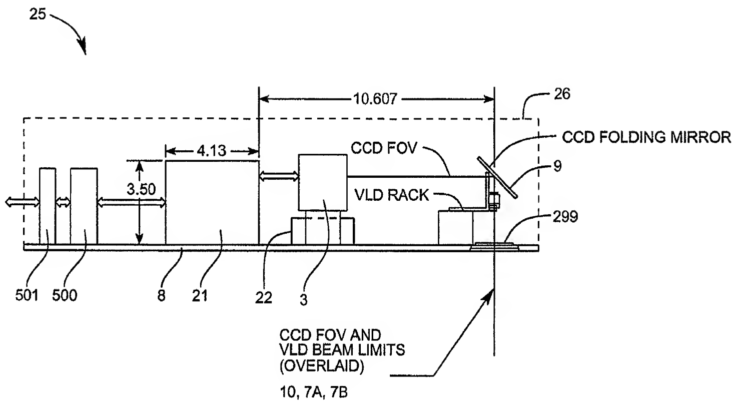

25
20.0"
12.2"
26
3.5"
6A
9
27
6B
11
11
299
299
8
3
FOV LIMITS
FOV LIMITS
FOV OF A
SINGLE PIXEL

FIG. 1G3



25
10.607
26
4.13
CCD FOV
CCD FOLDING MIRROR
9
3.50
VLD RACK
299
501
500
8
21
22
3
CCD FOV AND
VLD BEAM LIMITS
(OVERLAID)
10, 7A, 7B

FIG. 1G4

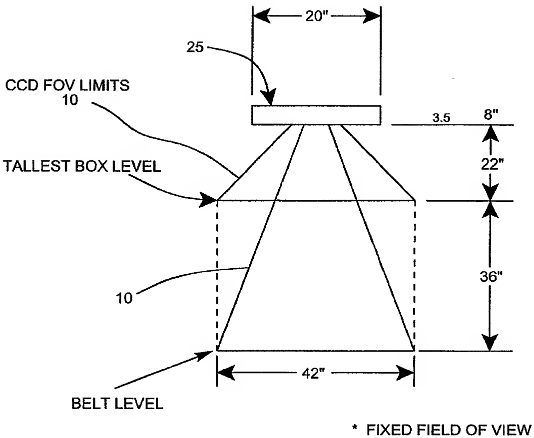

20"
25
CCD FOV LIMITS
10
3.5
8"
22"
TALLEST BOX LEVEL
36"
10
42"
BELT LEVEL
* FIXED FIELD OF VIEW

FIG. 1G5

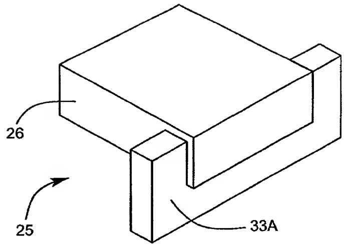


FIG. 1G6

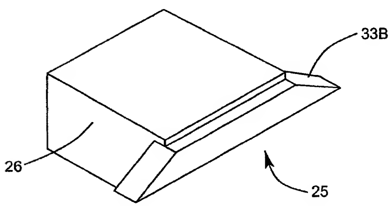


FIG. 1G7

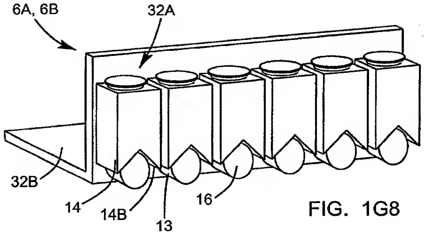


FIG. 1G8

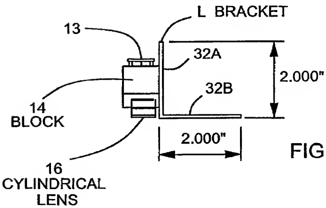


FIG. 1G9

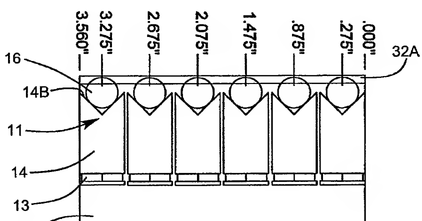


FIG. 1G10

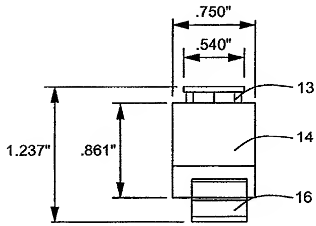


FIG. 1G11

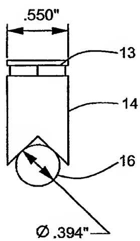


FIG. 1G12

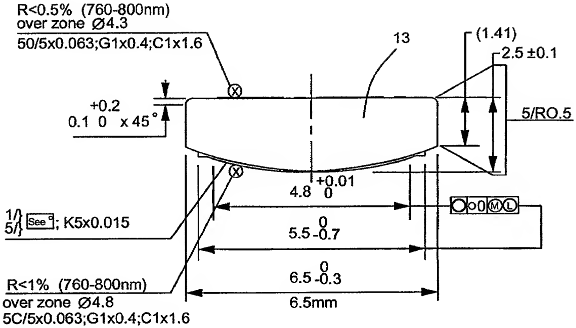


FIG. 1G13

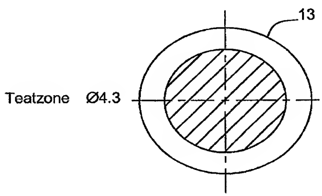


FIG. 1G14

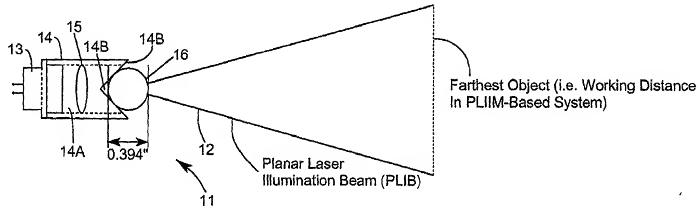


FIG. 1G15A

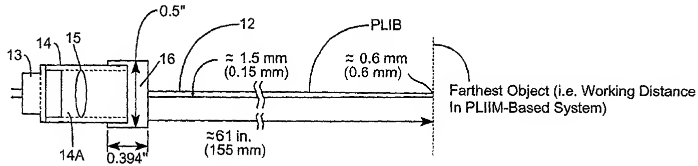


FIG. 1G15B

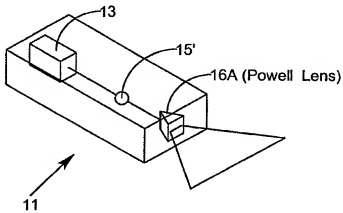


FIG. 1G16A

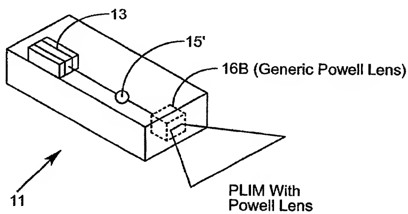


FIG. 1G16B

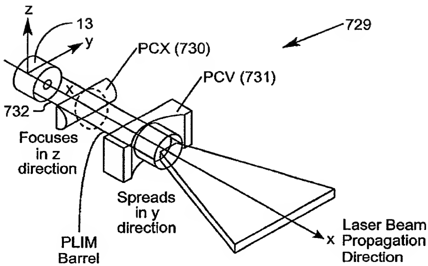


FIG. 1G17A

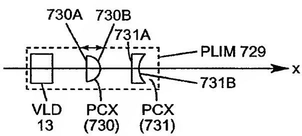


FIG. 1G17B

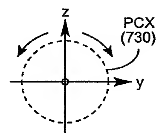


FIG. 1G17C

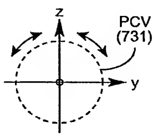


FIG. 1G17D

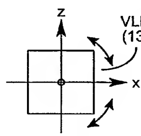


FIG. 1G17E

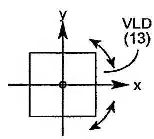


FIG. 1G17F

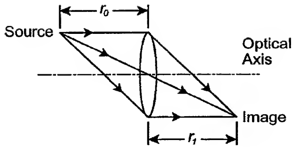


FIG. 1H1

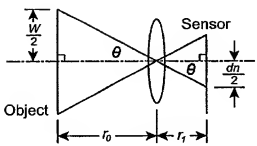


FIG. 1H2

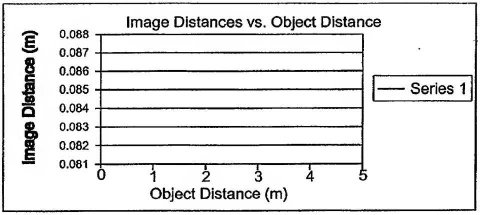


FIG. 1H3

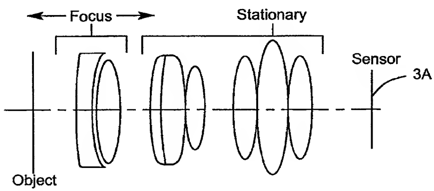


FIG. 1H4

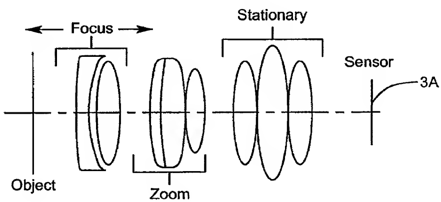


FIG. 1H5

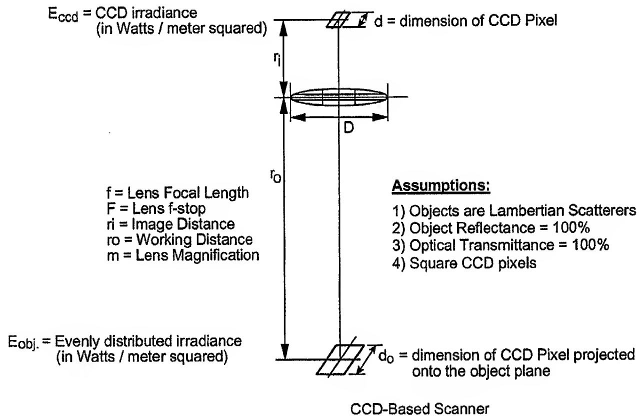

E_{ccd} = CCD irradiance
(in Watts / meter squared)
d = dimension of CCD Pixel
r_i
D
r_o
f = Lens Focal Length
F = Lens f-stop
ri = Image Distance
ro = Working Distance
m = Lens Magnification
Assumptions:
1) Objects are Lambertian Scatterers
2) Object Reflectance = 100%
3) Optical Transmittance = 100%
4) Square CCD pixels
$E_{obj.}$ = Evenly distributed irradiance
(in Watts / meter squared)
d_o = dimension of CCD Pixel projected
onto the object plane
CCD-Based Scanner

FIG. 1H6

FIRST GENERALIZED METHOD OF REDUCING SPECKLE-NOISE PATTERNS AT IMAGE DETECTION ARRAY OF THE IFD SUBSYSTEM (3)

(SPMF)

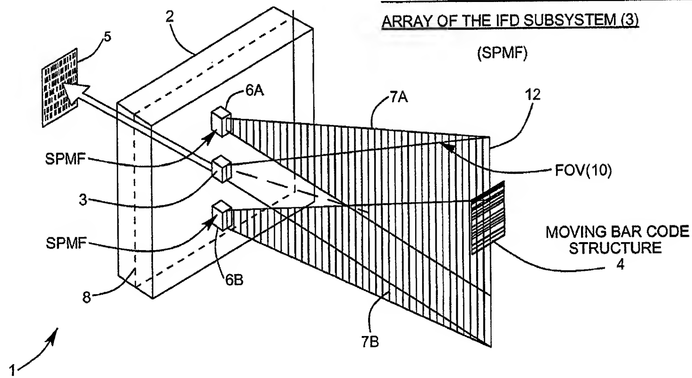


FIG. 1I1

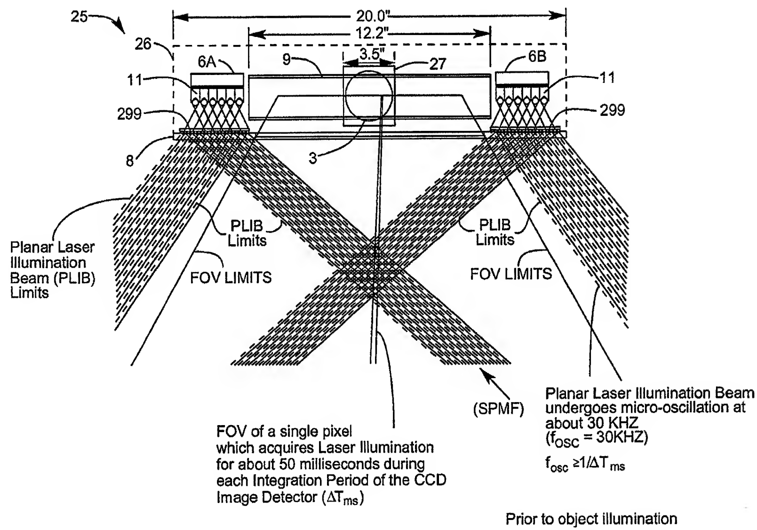

25
26
20.0"
12.2"
3.5"
6A
9
27
6B
11
11
299
299
8
3
Planar Laser Illumination Beam (PLIB) Limits
PLIB Limits
PLIB Limits
FOV LIMITS
FOV LIMITS
(SPMF)
Planar Laser Illumination Beam undergoes micro-oscillation at about 30 KHZ (f_{OSC} = 30KHZ)
$f_{osc} \geq 1/\Delta T_{ms}$
FOV of a single pixel which acquires Laser Illumination for about 50 milliseconds during each Integration Period of the CCD Image Detector (ΔT_{ms})
Prior to object illumination

FIG. 1I2A

THE FIRST GENERALIZED SPECKLE-NOISE PATTERN REDUCTION METHOD OF THE PRESENT INVENTION

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial phase of the transmitted PLIB along the planar extent thereof according to a spatial phase modulation function (SPMF) so as to produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

A

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the power of the speckle-noise pattern observed at the image detection array.

B

FIG. 1I2B

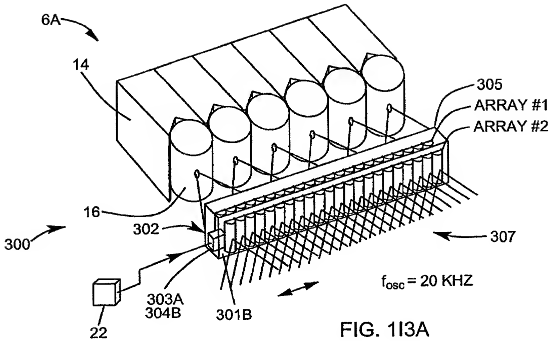


FIG. 1I3A

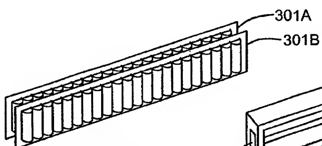


FIG. 1I3B

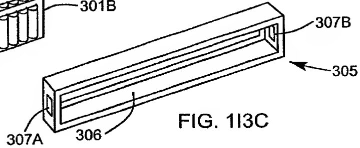


FIG. 1I3C

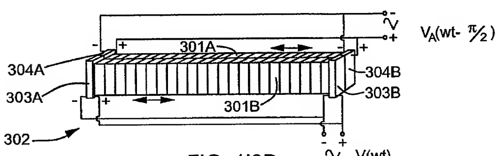


FIG. 1I3D

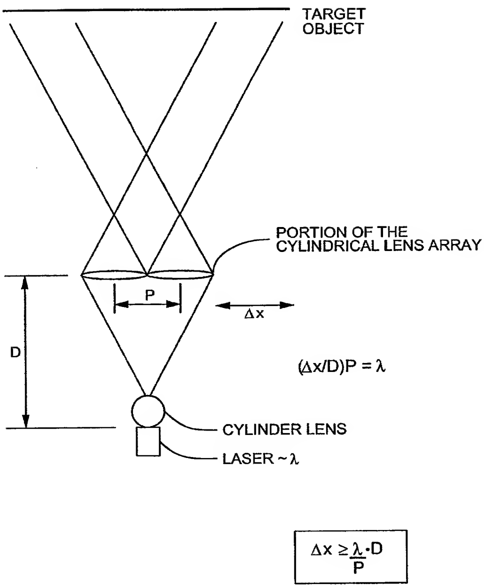

TARGET OBJECT
PORTION OF THE CYLINDRICAL LENS ARRAY
P
Δx
D
(Δx/D)P = λ
CYLINDER LENS
LASER ~ λ
Δx ≥ λ/P · D

FIG. 1I3E

FIG. 113F

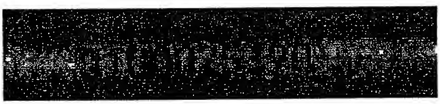


FIG. 113G

10067540.070602

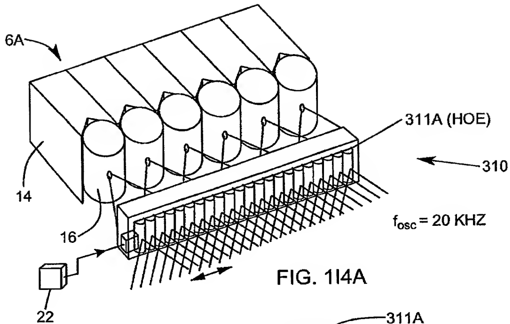


FIG. 114A

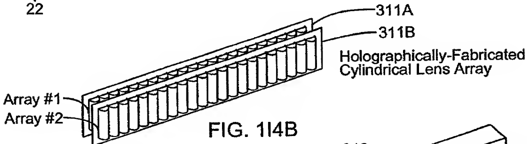


FIG. 114B

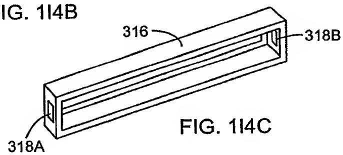


FIG. 114C

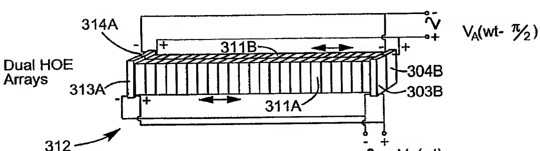


FIG. 114D

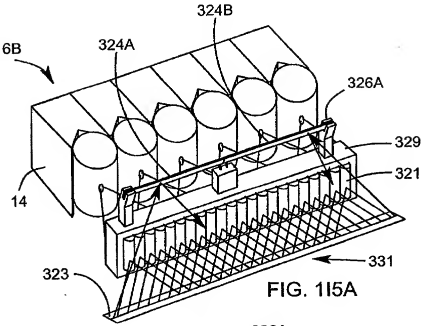


FIG. 1I5A

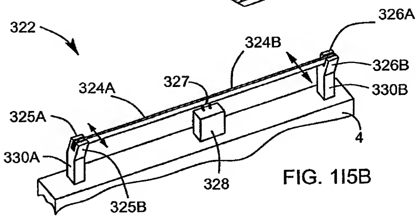


FIG. 1I5B

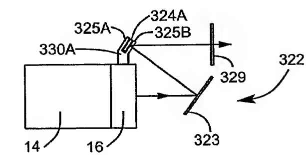


FIG. 1I5C

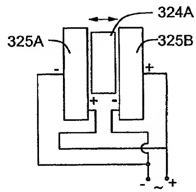


FIG. 1I5D

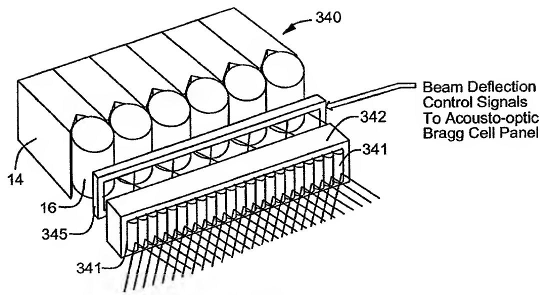


FIG. 116A

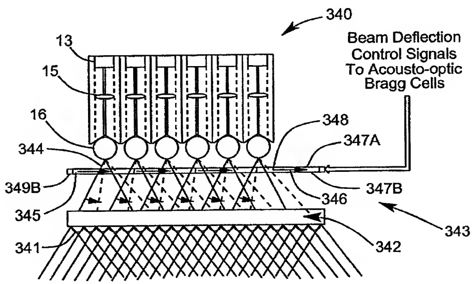


FIG. 116B

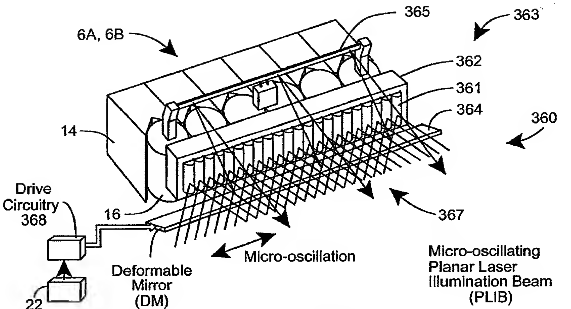


FIG. 1I7A

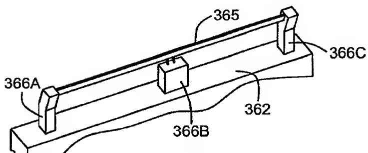


FIG. 1I7B

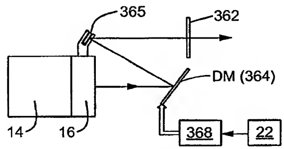


FIG. 1I7C

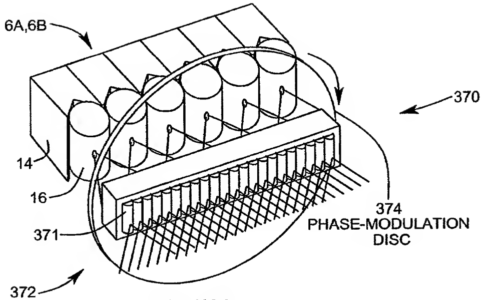


FIG. 118A

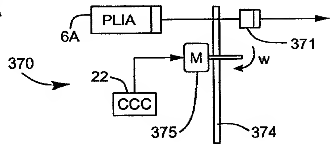


FIG. 118B

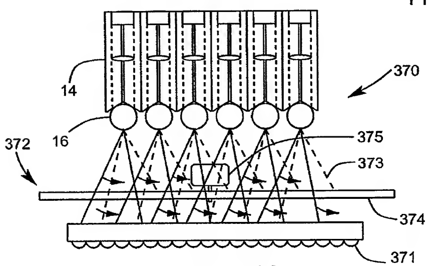


FIG. 118C

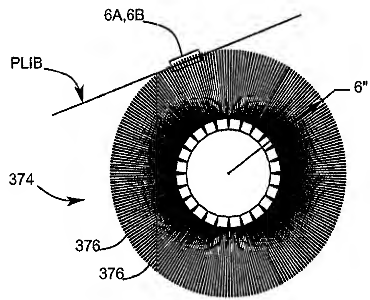


FIG. 118D

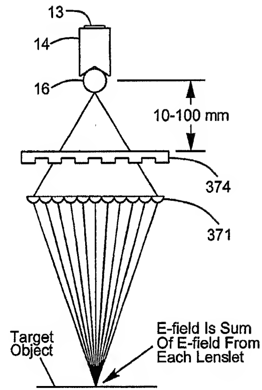


FIG. 118E

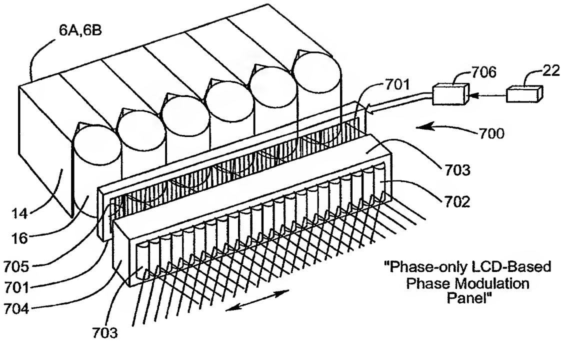


FIG. 1I8F

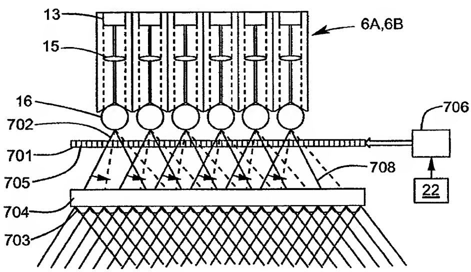


FIG. 1I8G

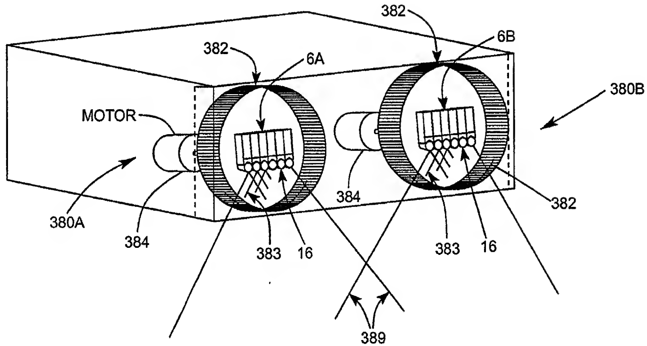
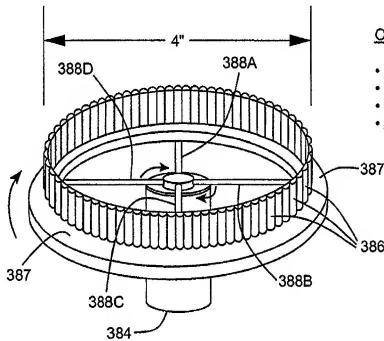


FIG. 1I9A



<u>Optical Specifications:</u>

- 30 Cylindrical Lens (Lines) Per Linear Inch
- Focal Length ≈ 20 Millimeters
- Diameter Of Lenticular Carousel ≈ 4 Inches
- Acrylic Material

FIG. 1I9B

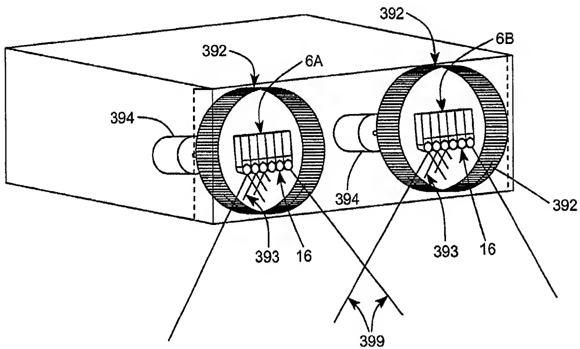
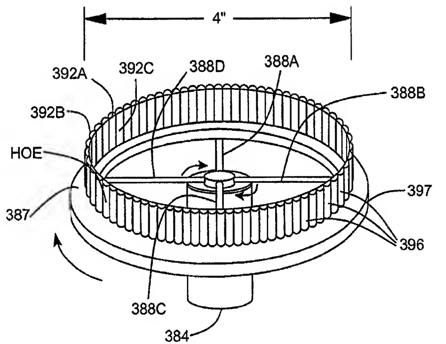


FIG. 1I10A



Optical Specifications:

- 30 Cylindrical Lens (Lines) Per Linear Inch
- Focal Length ≈ 20 Millimeters
- Diameter Of Lenticular Carousel ≈ 4 Inches

FIG. 1I10B

10062540 " 020902

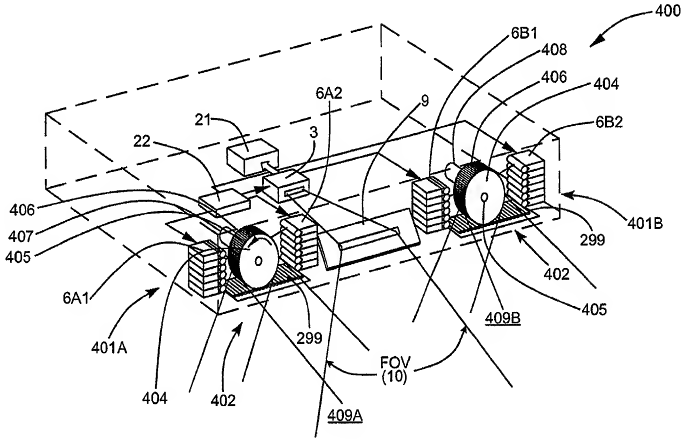


FIG. 1I11A

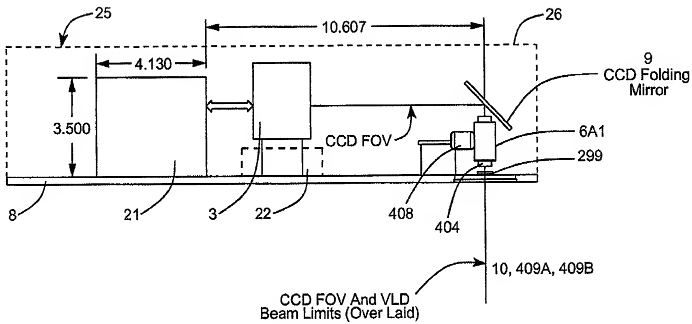

25
26
10.607
4.130
3.500
9
CCD Folding
Mirror
6A1
299
CCD FOV
8
21
3
22
408
404
10, 409A, 409B
CCD FOV And VLD
Beam Limits (Over Laid)

FIG. 1I11B

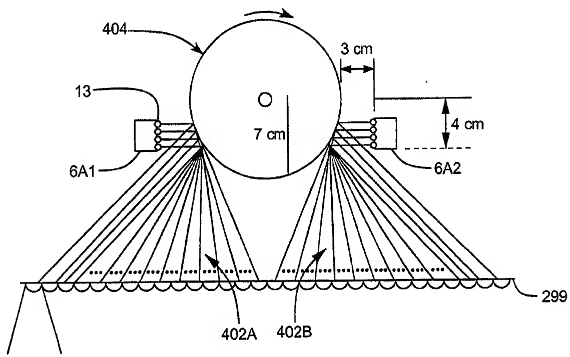


FIG. 1I11C

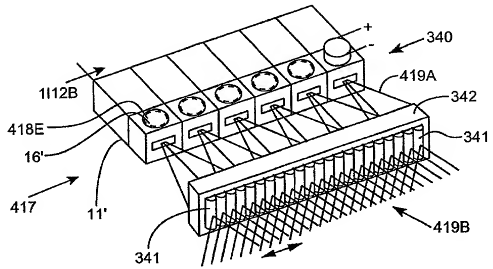


FIG. 1I12A

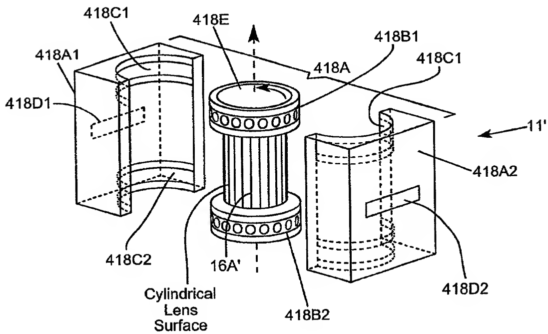


FIG. 1I12B

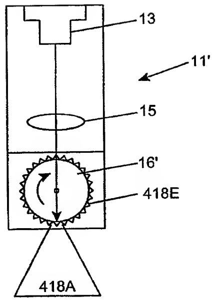


FIG. 1I12C

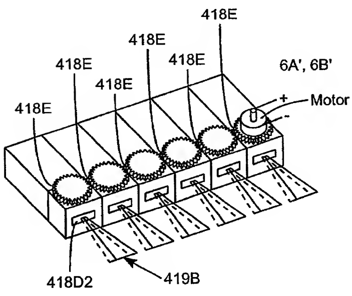


FIG. 1I12D

Second Generalized Method Of
Reducing Speckle-Noise Patterns
At Image Detection Array
Of The IFD Subsystem (3)

(TIMF)

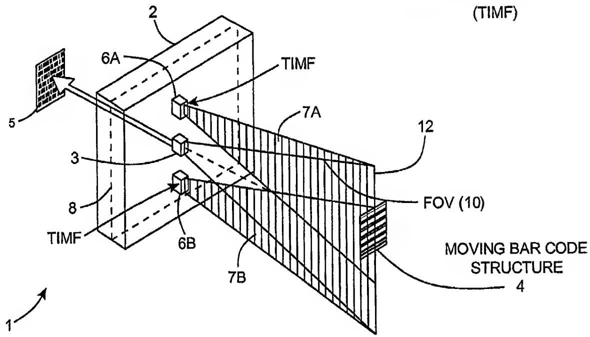


FIG. 1I13

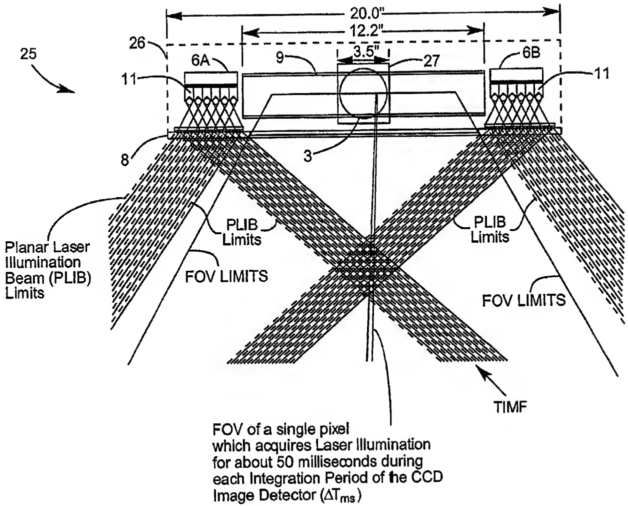

20.0"
12.2"
3.5"
25
26
6A
9
27
6B
11
11
8
3
Planar Laser Illumination Beam (PLIB) Limits
PLIB Limits
PLIB Limits
FOV LIMITS
FOV LIMITS
TIMF
FOV of a single pixel which acquires Laser Illumination for about 50 milliseconds during each Integration Period of the CCD Image Detector (ΔT_{ms})

FIG. 1I13A

THE SECOND GENERALIZED SPECKLE-NOISE PATTERN REDUCTION METHOD OF THE PRESENT INVENTION

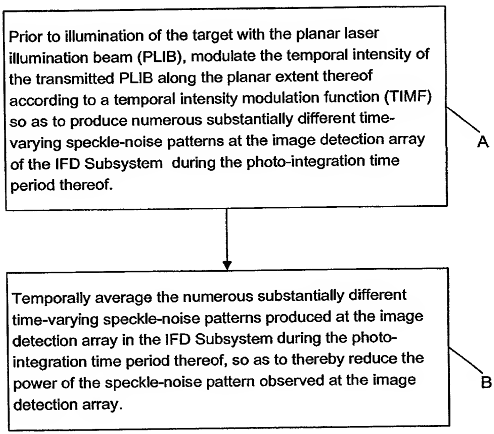


FIG. 1I13B

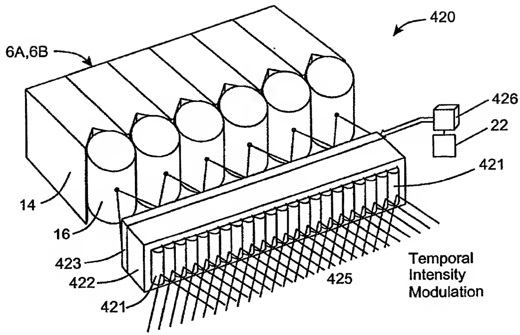


FIG. 1I14A

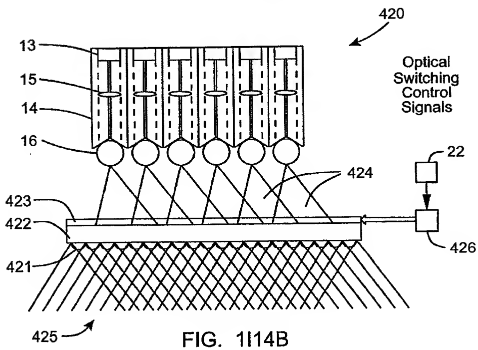


FIG. 1I14B

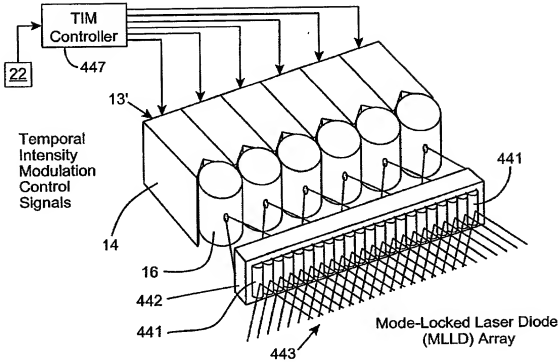


FIG. 1I15A

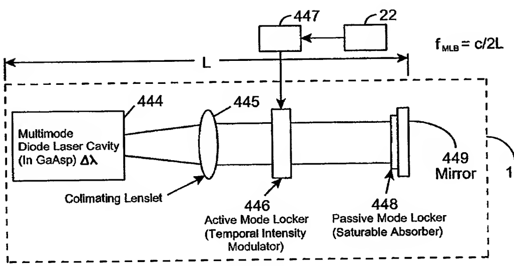


FIG. 1I15B

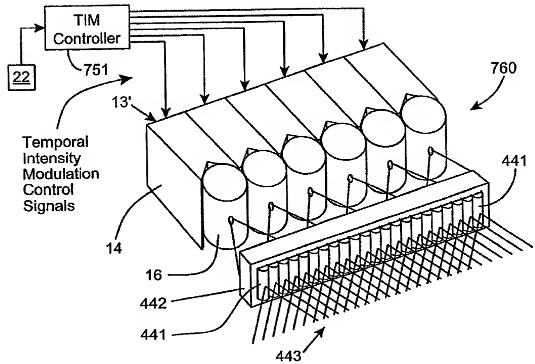


FIG. 1I15C

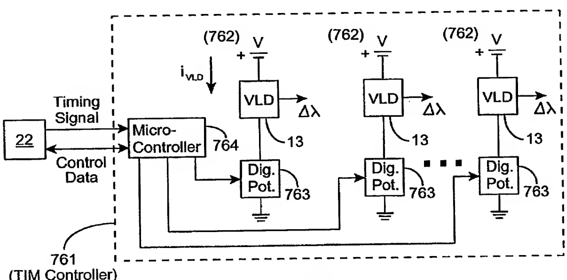


FIG. 1I15D

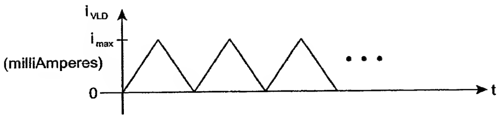


FIG. 1I15E

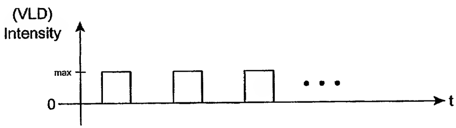


FIG. 1I15F

<u>Third Generalized Method Of Reducing Speckle-Noise Patterns At Image Detection Array Of The IFD Subsystem (3)</u>

(TIMF)

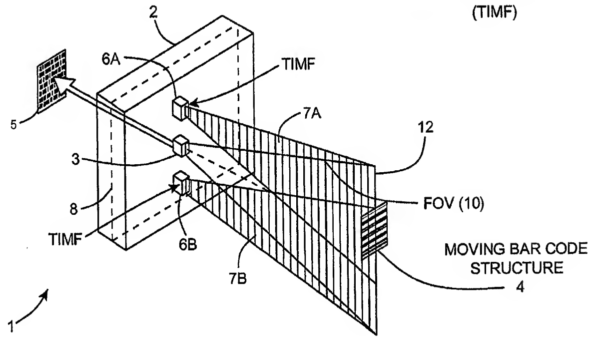
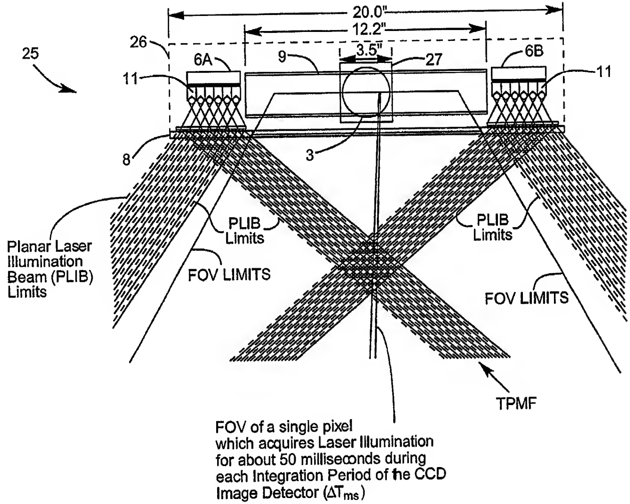


FIG. 1I16



20.0"
12.2"
3.5"
25
26
6A
9
27
6B
11
11
8
3
PLIB Limits
PLIB Limits
Planar Laser Illumination Beam (PLIB) Limits
FOV LIMITS
FOV LIMITS
TPMF
FOV of a single pixel which acquires Laser Illumination for about 50 milliseconds during each Integration Period of the CCD Image Detector (ΔT_{ms})

FIG. 1I16A

THE THIRD GENERALIZED SPECKLE-NOISE PATTERN REDUCTION METHOD OF THE PRESENT INVENTION

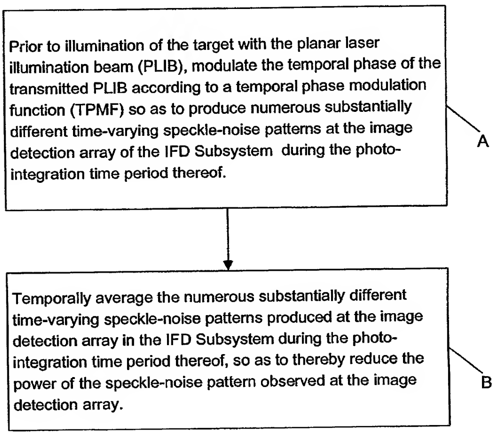


FIG. 1I16B

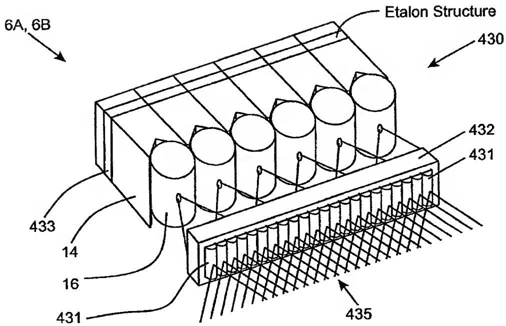


FIG. 1I17A

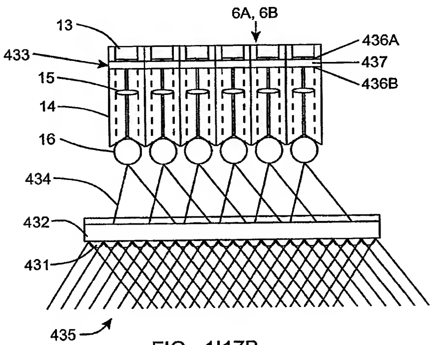


FIG. 1I17B

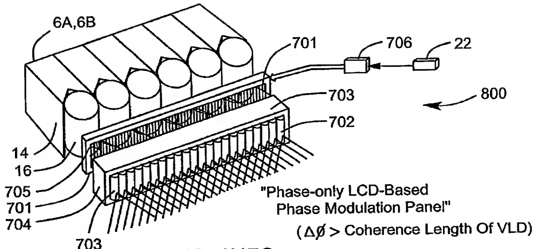


FIG. 1I17C

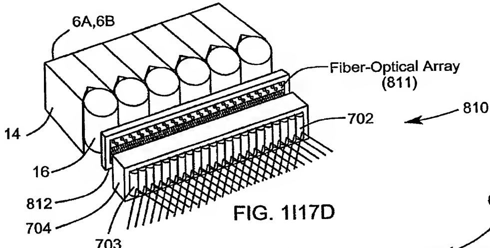


FIG. 1I17D

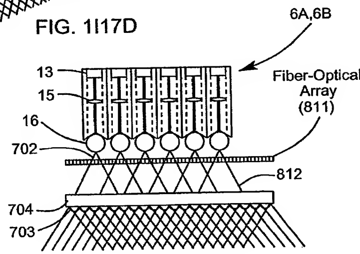


FIG. 1I17E

Fourth Generalized Method Of
Reducing Speckle-Noise Patterns
At Image Detection Array
Of The IFD Subsystem (3)

(TFMF)

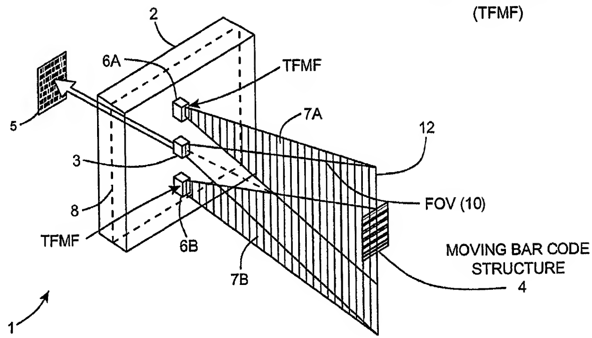
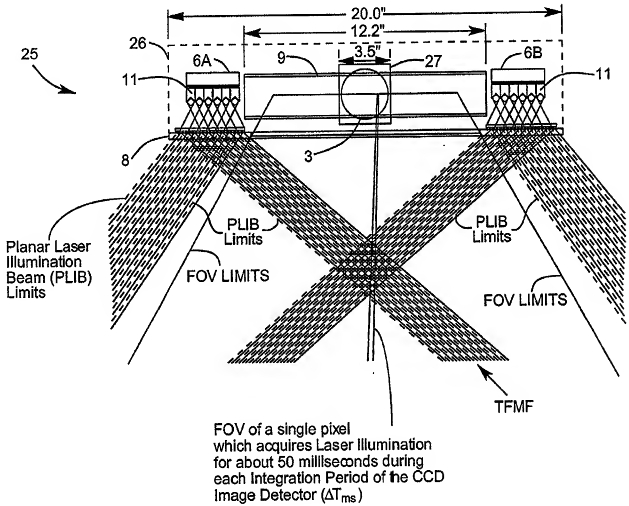


FIG. 1I18



20.0"
12.2"
3.5"
25
26
6A
9
27
6B
11
11
8
3
Planar Laser Illumination Beam (PLIB) Limits
PLIB Limits
PLIB Limits
FOV LIMITS
FOV LIMITS
TFMF
FOV of a single pixel which acquires Laser Illumination for about 50 milliseconds during each Integration Period of the CCD Image Detector (ΔT_{ms})

FIG. 1I18A

THE FOURTH GENERALIZED SPECKLE-NOISE PATTERN REDUCTION METHOD OF THE PRESENT INVENTION

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the temporal frequency of the transmitted PLIB along the planar extent thereof according to a temporal intensity modulation function (TIMF) so as to produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

A

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the power of the speckle-noise pattern observed at the image detection array.

B

FIG. 1I18B

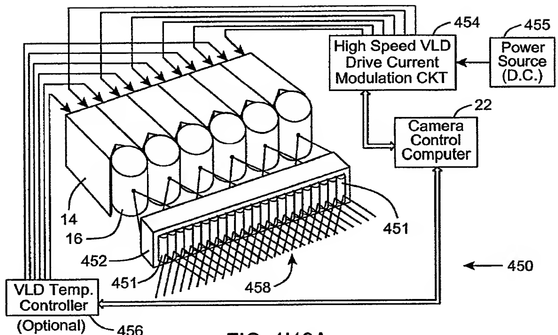


FIG. 1I19A

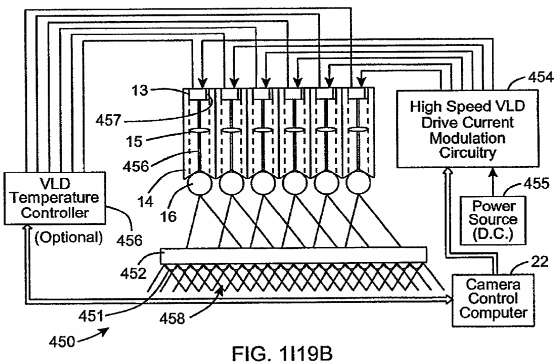


FIG. 1I19B

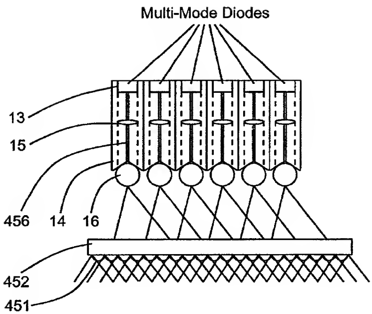


FIG. 1I19C

Fifth Generalized Method Of
Reducing Speckle-Noise Patterns
At Image Detection Array
Of The IFD Subsystem (3)

(SIMF)

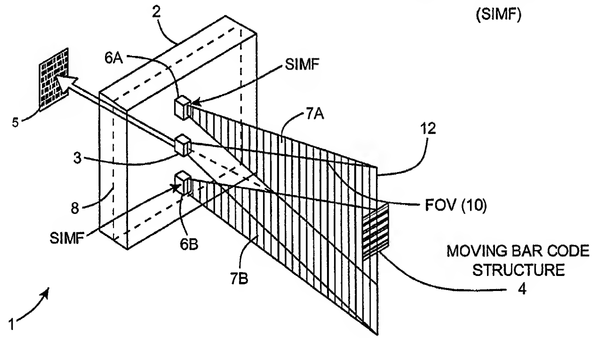


FIG. 1I20

20060207 0452900T

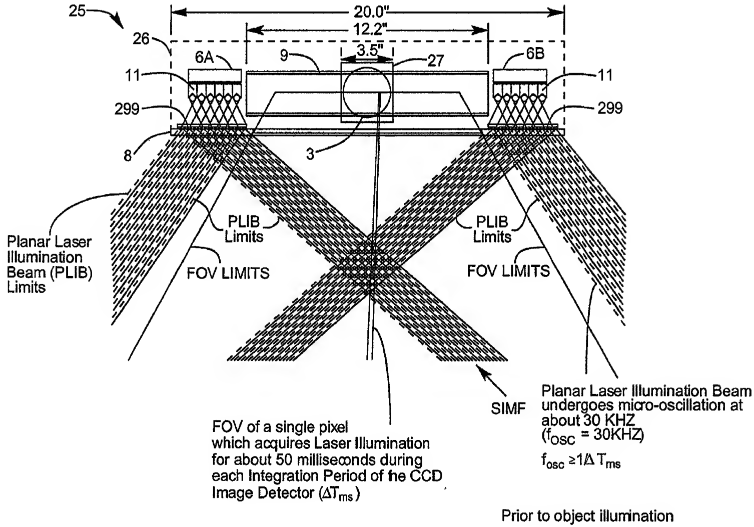


FIG. 1I20A

THE FIFTH GENERALIZED SPECKLE-NOISE PATTERN REDUCTION METHOD OF THE PRESENT INVENTION

Prior to illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial intensity of the transmitted PLIB along the planar extent thereof according to a spatial intensity modulation function (SIMF) so as to produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

A

↓

Temporally average the numerous substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the power of the speckle-noise pattern observed at the image detection array.

B

FIG. 1I20B

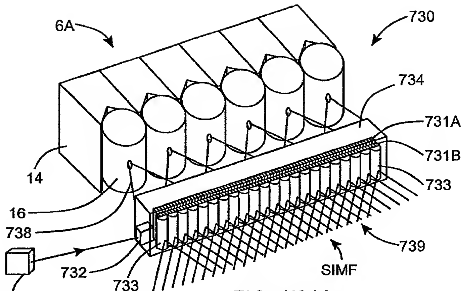


FIG. 1I21A

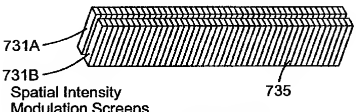


FIG. 1I21B

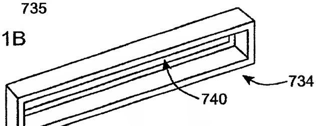


FIG. 1I21C

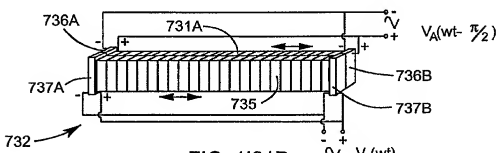


FIG. 1I21D

Sixth Generalized Method Of
Reducing Speckle-Noise Patterns
At Image Detection Array
Of The IFD Subsystem (3)

(SIMF)

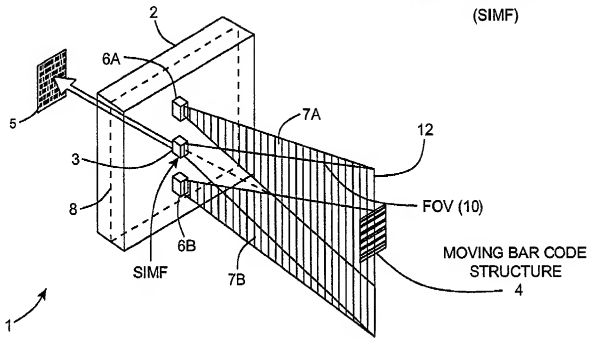


FIG. 1I22

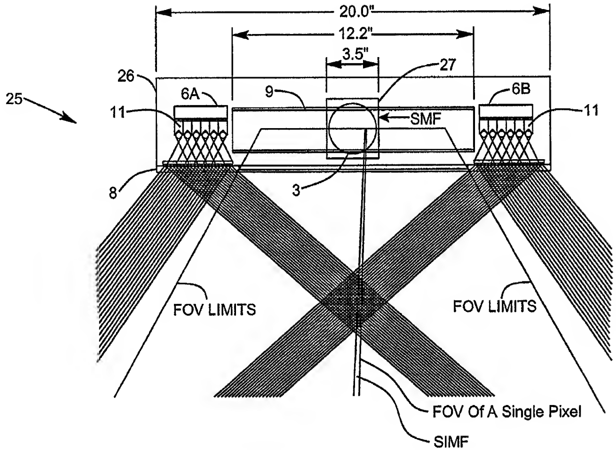

20.0"
12.2"
3.5"
27
26
6A
9
6B
25
11
SMF
11
8
3
FOV LIMITS
FOV LIMITS
FOV Of A Single Pixel
SIMF

FIG. 1I22A

THE SIXTH GENERALIZED SPECKLE-NOISE PATTERN REDUCTION METHOD OF THE PRESENT INVENTION

After illumination of the target with the planar laser illumination beam (PLIB), modulate the spatial intensity of the reflected/scattered (i.e. received) PLIB along the planar extent thereof according to a spatial intensity modulation function (SIMF) so as to produce numerous substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

A

Temporally average the many substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the speckle-noise pattern observed at the image detection array.

B

FIG. 1I22B

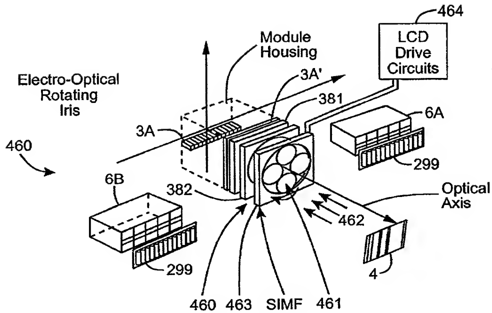


FIG. 1I23A

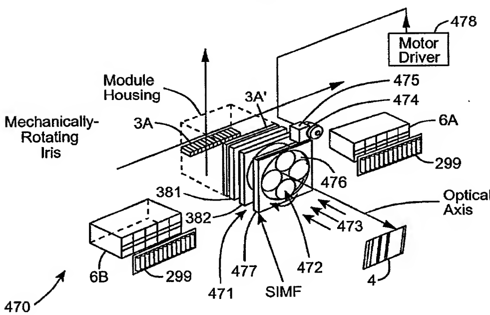


FIG. 1I23B

Seventh Generalized Method Of Reducing Speckle-Noise Patterns At Image Detection Array Of The IFD Subsystem (3)

(TIMF)

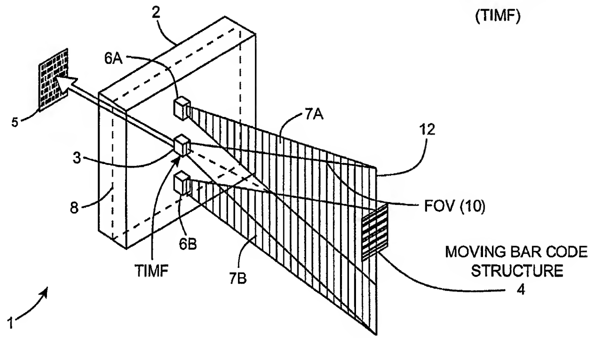


FIG. 1I24

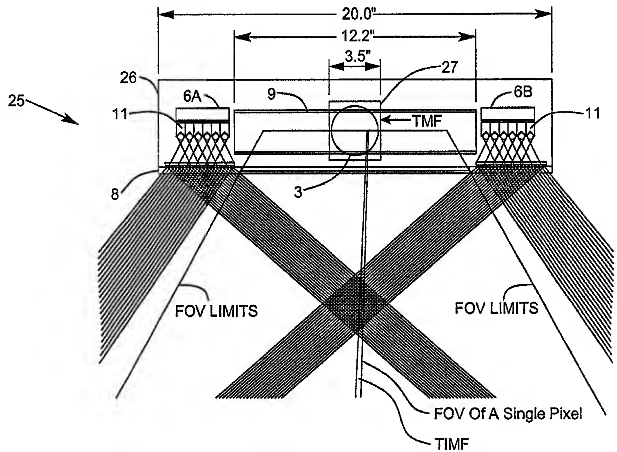

20.0"
12.2"
3.5"
27
26
25
6A
9
6B
11
TMF
11
8
3
FOV LIMITS
FOV LIMITS
FOV Of A Single Pixel
TIMF

FIG. 1I24A

THE SEVENTH GENERALIZED SPECKLE-NOISE PATTERN REDUCTION METHOD OF THE PRESENT INVENTION

After illumination of the target with the planar laser illumination beam (PLIB), modulate the temporal intensity of the reflected/scattered (i.e. received) PLIB along the planar extent thereof according to a temporal intensity modulation function (TIMF) so as to produce many substantially different time-varying speckle-noise patterns at the image detection array of the IFD Subsystem during the photo-integration time period thereof.

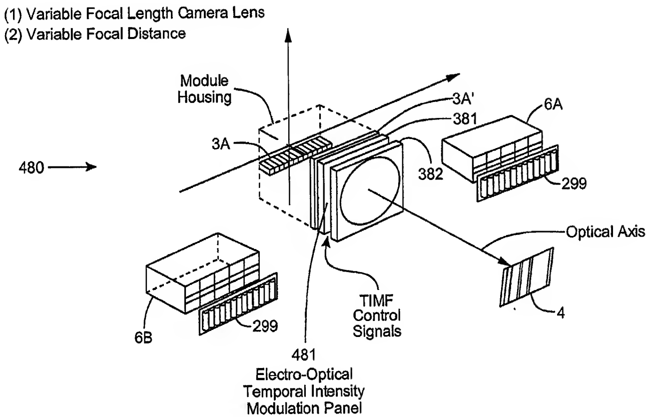
A

↓

Temporally average the many substantially different time-varying speckle-noise patterns produced at the image detection array in the IFD Subsystem during the photo-integration time period thereof, so as to thereby reduce the speckle-noise pattern observed at the image detection array.

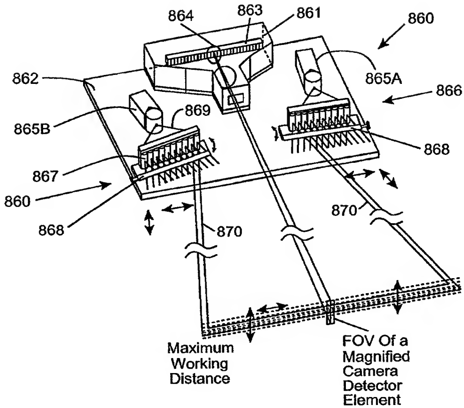
B

FIG. 1I24B



(1) Variable Focal Length Camera Lens
(2) Variable Focal Distance
480
Module Housing
3A
3A'
381
382
6A
299
Optical Axis
4
6B
299
481
Electro-Optical Temporal Intensity Modulation Panel
TIMF Control Signals

FIG. 1I24C



* Lateral And Transverse Micro-oscillation Of PLIB

FIG. 1I25A1

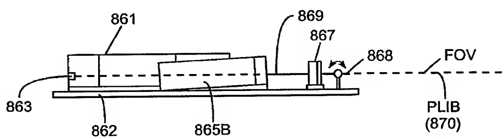


FIG. 1I25A2

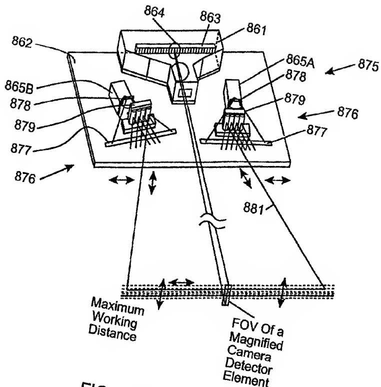


FIG. 1I25B1

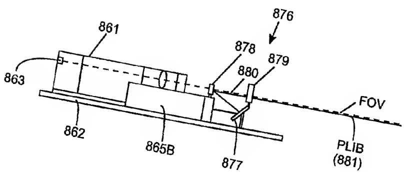
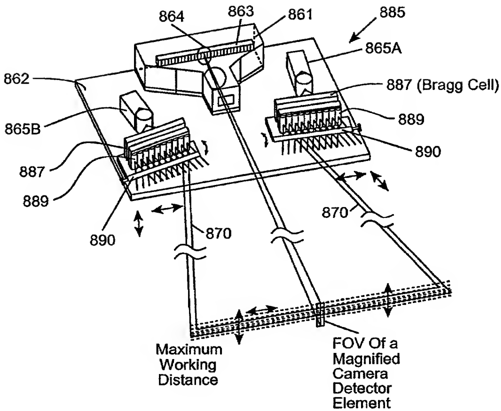


FIG. 1I25B2



* Lateral And
Transverse
Micro-oscillation
Of PLIB

FIG. 1I25C1

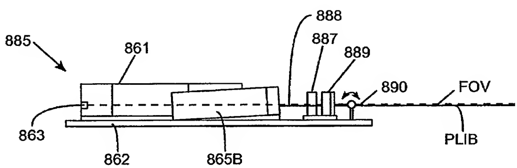


FIG. 1I25C2

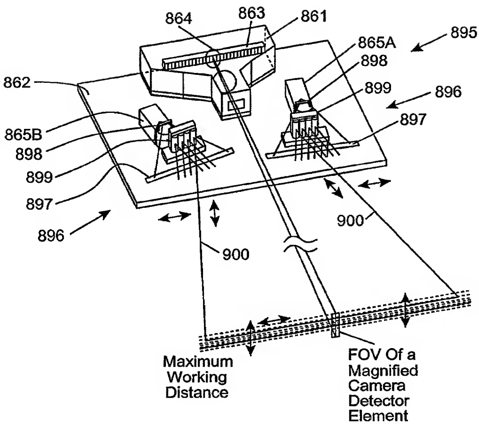


FIG. 1I25D1

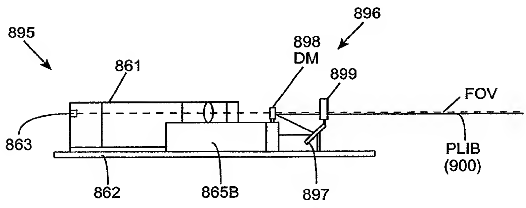
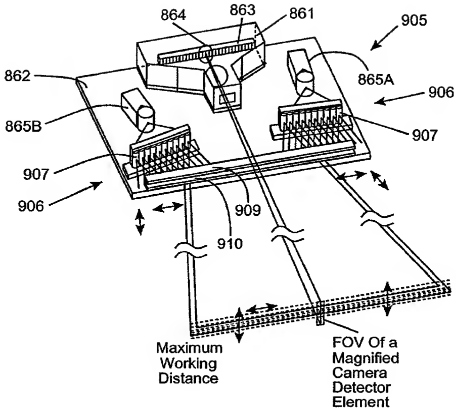


FIG. 1I25D2



* Lateral And Transverse Micro-oscillation Of PLIB

FIG. 1I25E1

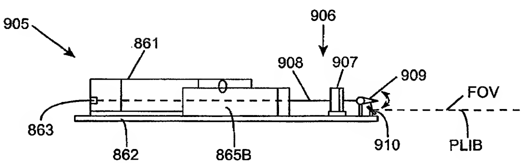
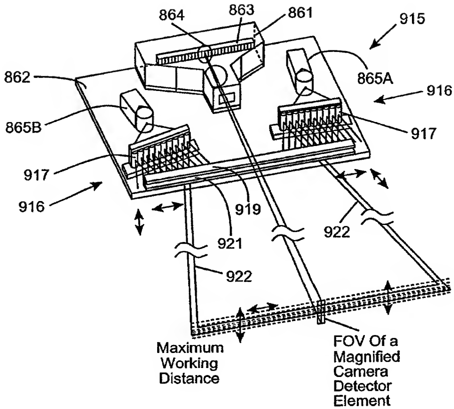


FIG. 1I25E2



* Lateral And Transverse Micro-oscillation Of PLIB

FIG. 1I25F1

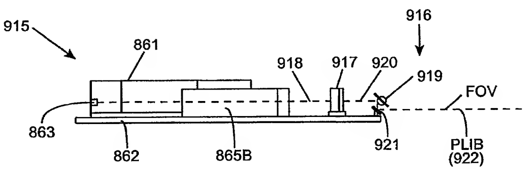
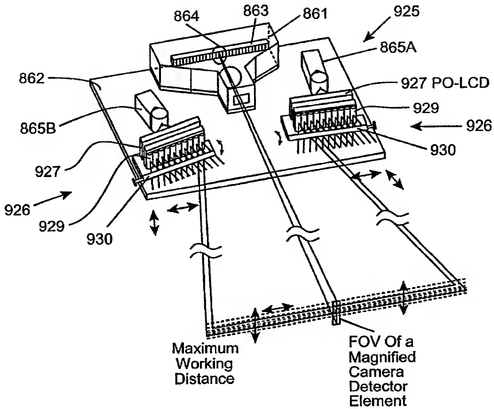


FIG. 1I25F2



* Lateral And Transverse Micro-oscillation Of PLIB

FIG. 1I25G1

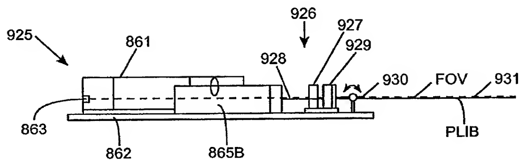
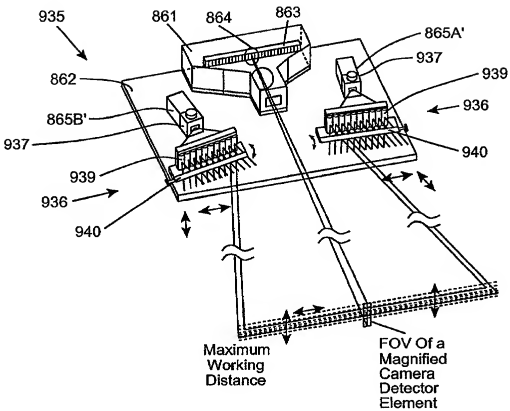


FIG. 1I25G2



* Lateral And Transverse Micro-oscillation Of PLIB

FIG. 1I25H1

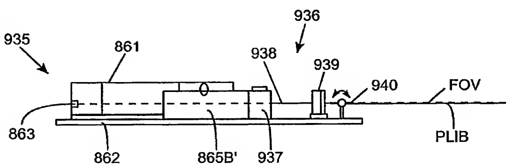


FIG. 1I25H2

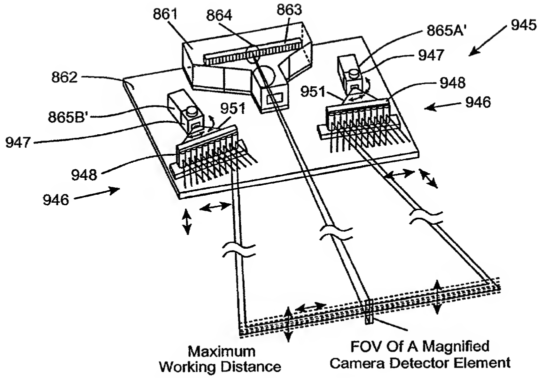


FIG. 1I25I1

* Lateral And
Transverse
Micro-oscillation
Of PLIB

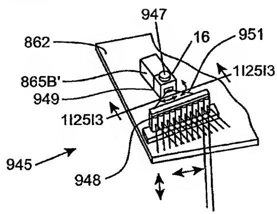


FIG. 1I25I2

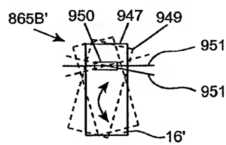


FIG. 1I25I3

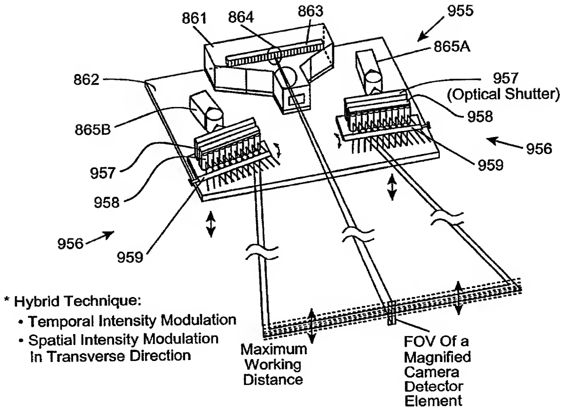


FIG. 1I25J1

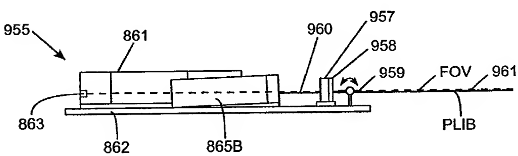


FIG. 1I25J2

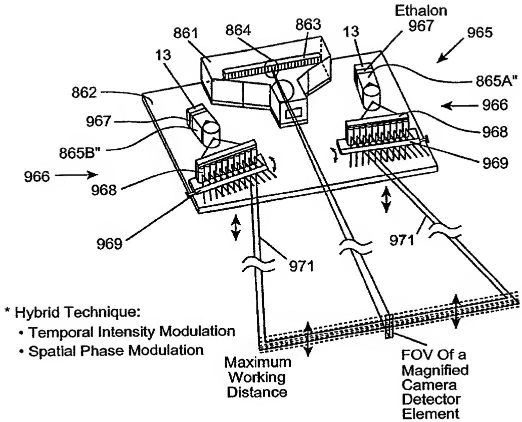


FIG. 1I25K1

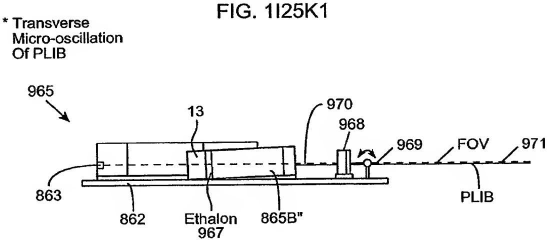


FIG. 1I25K2

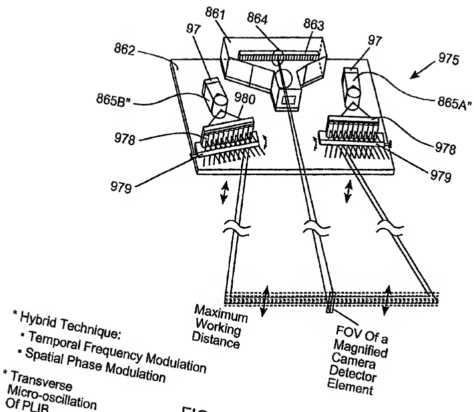


FIG. 1I25L1

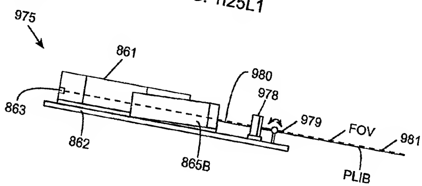
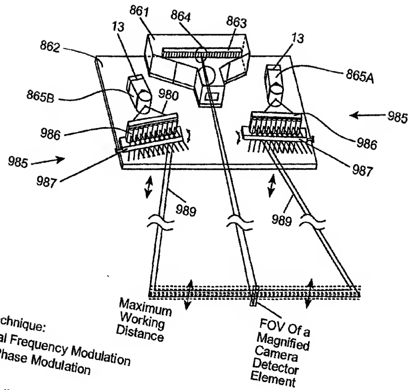


FIG. 1I25L2



* Hybrid Technique:
  • Temporal Frequency Modulation
  • Spatial Phase Modulation

* Transverse Micro-oscillation Of PLIB

FIG. 1I25M1

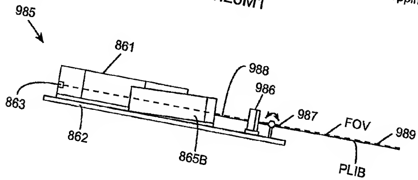


FIG. 1I25M2

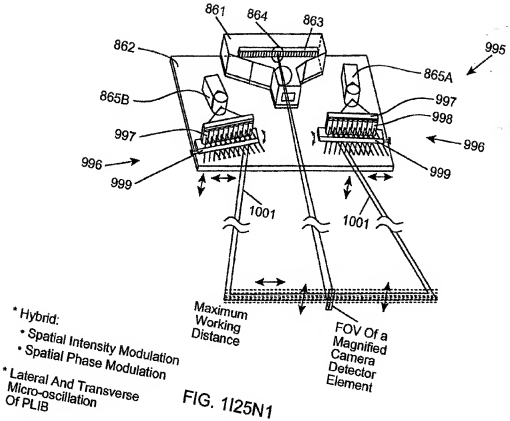


FIG. 1I25N1

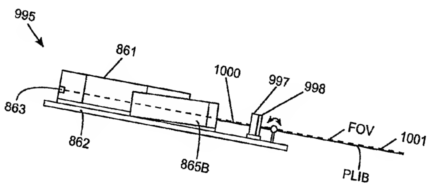


FIG. 1I25N2

Fixed Focal Length

Lens Cases

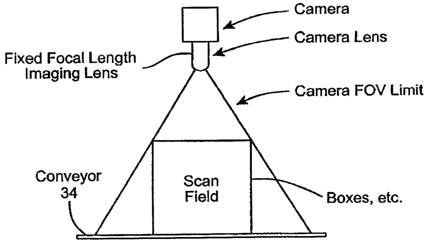


FIG. 1K1

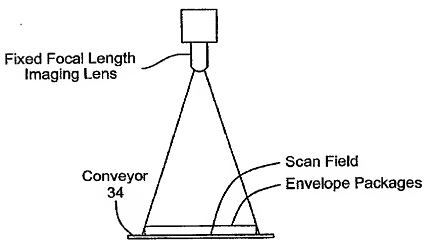


FIG. 1K2

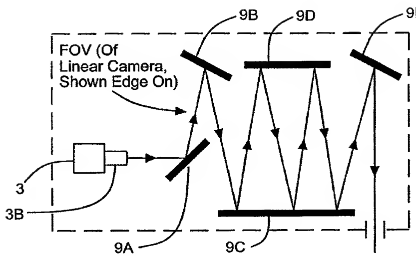


FIG. 1L1

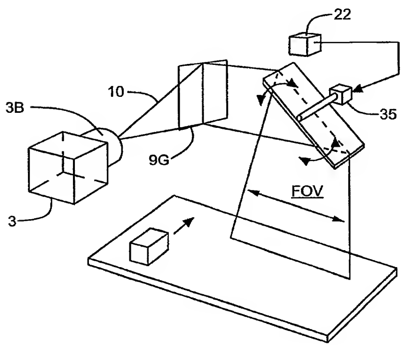


FIG. 1L2

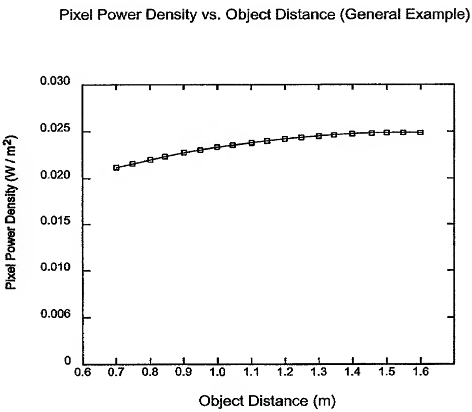

Pixel Power Density vs. Object Distance (General Example)
0.030
0.025
0.020
0.015
0.010
0.006
0
Pixel Power Density (W / m²)
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
Object Distance (m)

FIG. 1M1

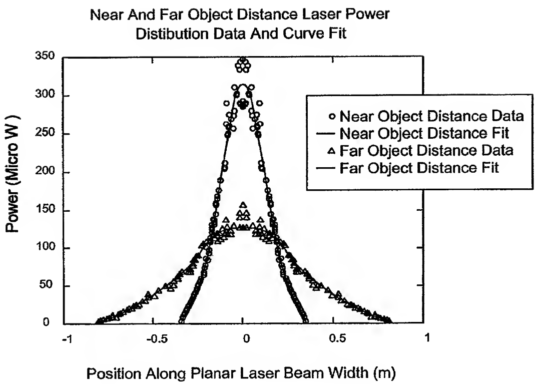

Near And Far Object Distance Laser Power
Distibution Data And Curve Fit
Power (Micro W)
350
300
250
200
150
100
50
0
-1
-0.5
0
0.5
1
Position Along Planar Laser Beam Width (m)
Near Object Distance Data
Near Object Distance Fit
Far Object Distance Data
Far Object Distance Fit

FIG. 1M2

Planar Laser Beam Width vs. Object Distance

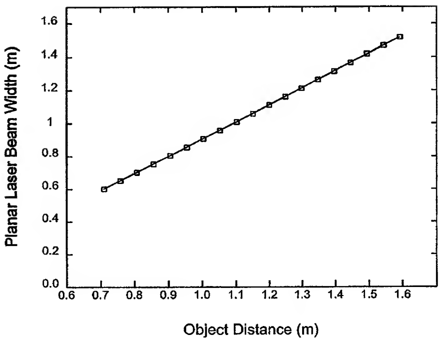


FIG. 1M3

Planar Laser Beam Height vs.
Object Distance (Far Object Distance Focus)

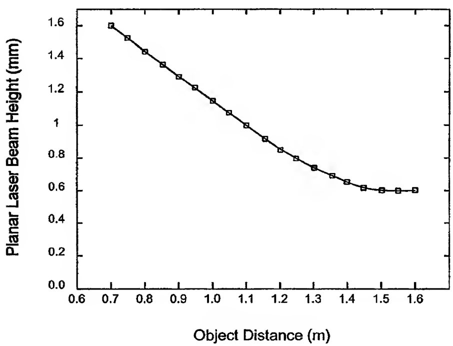


FIG. 1M4

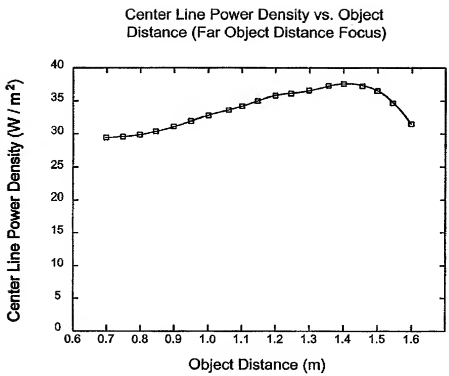

Center Line Power Density vs. Object Distance (Far Object Distance Focus)
Center Line Power Density (W / m²)
0
5
10
15
20
25
30
35
40
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
Object Distance (m)

FIG. 1N

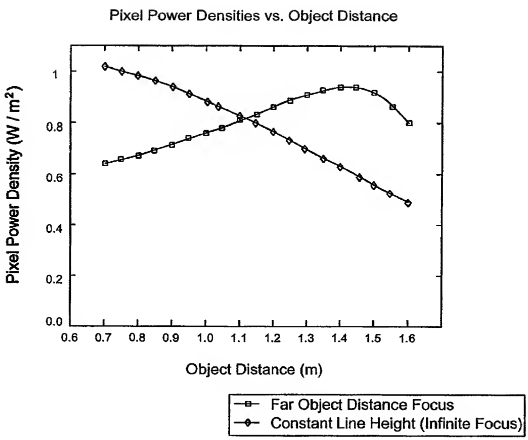

Pixel Power Densities vs. Object Distance
Pixel Power Density (W / m²)
1
0.8
0.6
0.4
0.2
0.0
0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
Object Distance (m)
Far Object Distance Focus
Constant Line Height (Infinite Focus)

FIG. 10

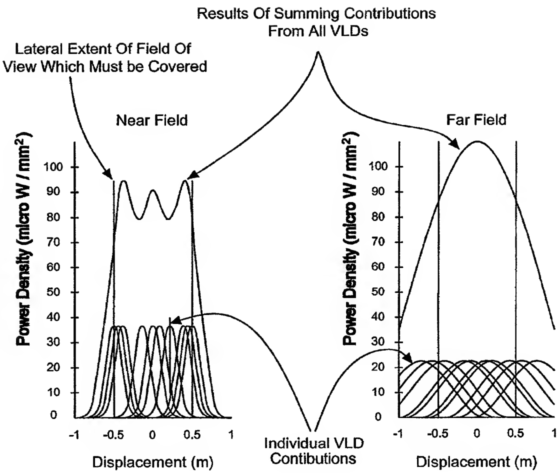


FIG. 1P1

FIG. 1P2

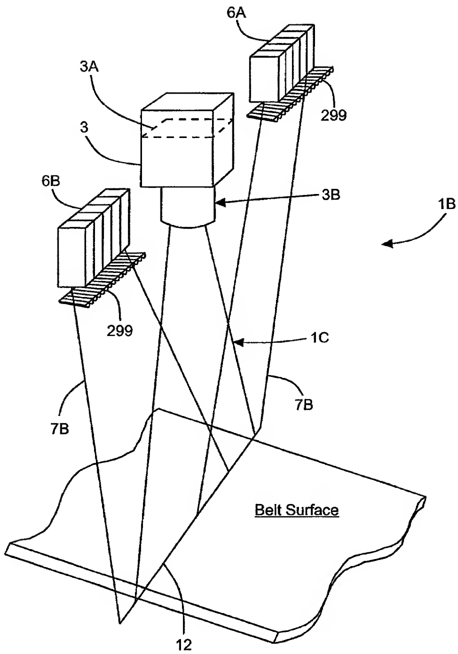


FIG. 1Q1

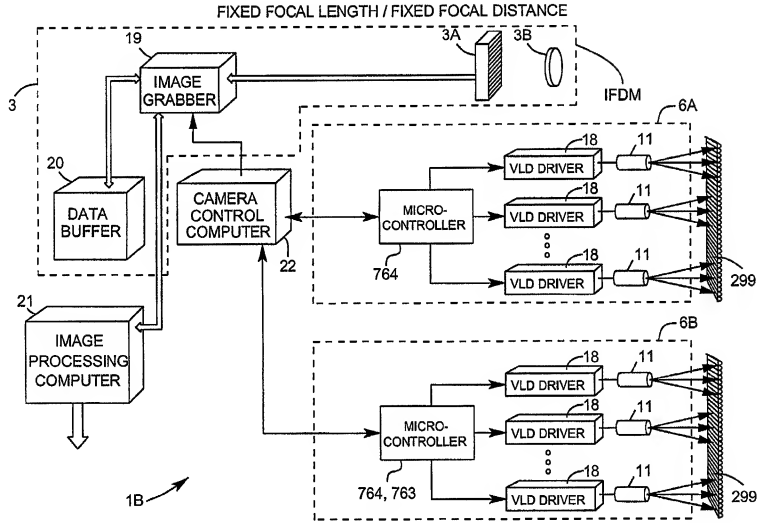

FIXED FOCAL LENGTH / FIXED FOCAL DISTANCE
3
19
IMAGE GRABBER
3A
3B
IFDM
6A
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
18
VLD DRIVER
11
299
21
IMAGE PROCESSING COMPUTER
6B
764, 763
1B

FIG. 1Q2

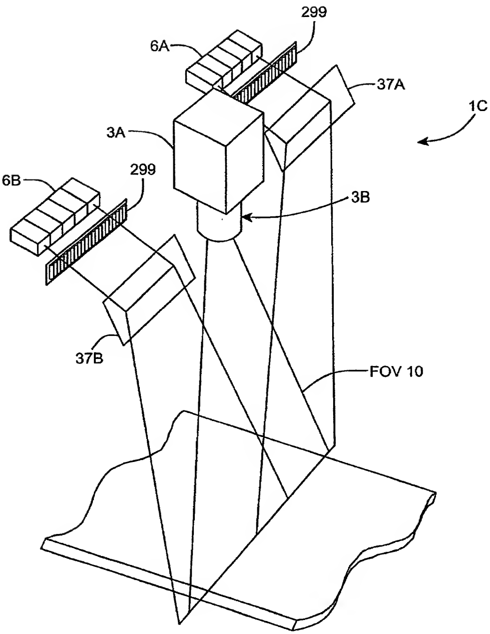


FIG. 1R1

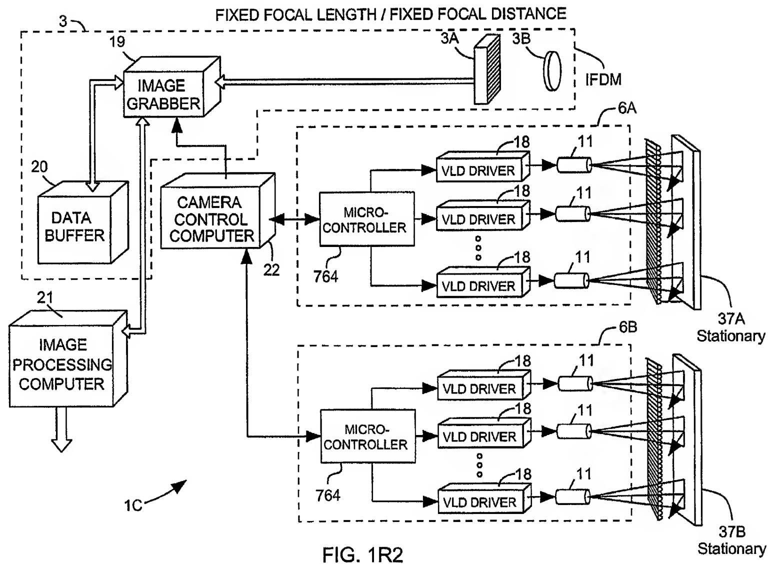

FIXED FOCAL LENGTH / FIXED FOCAL DISTANCE
3
19
IMAGE GRABBER
3A
3B
IFDM
6A
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
VLD DRIVER
18
11
37A Stationary
21
IMAGE PROCESSING COMPUTER
6B
37B Stationary
1C

FIG. 1R2

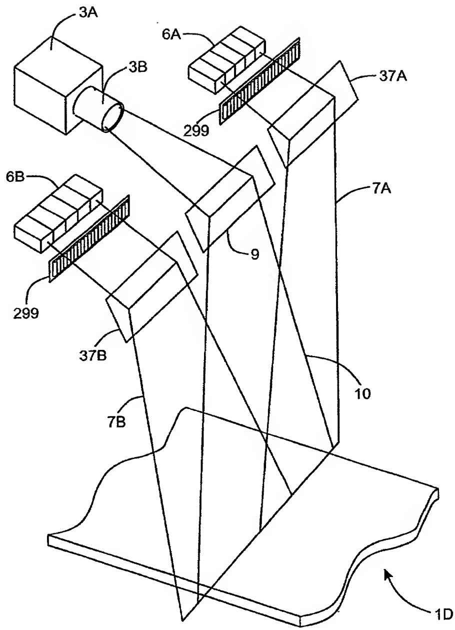


FIG. 1S1

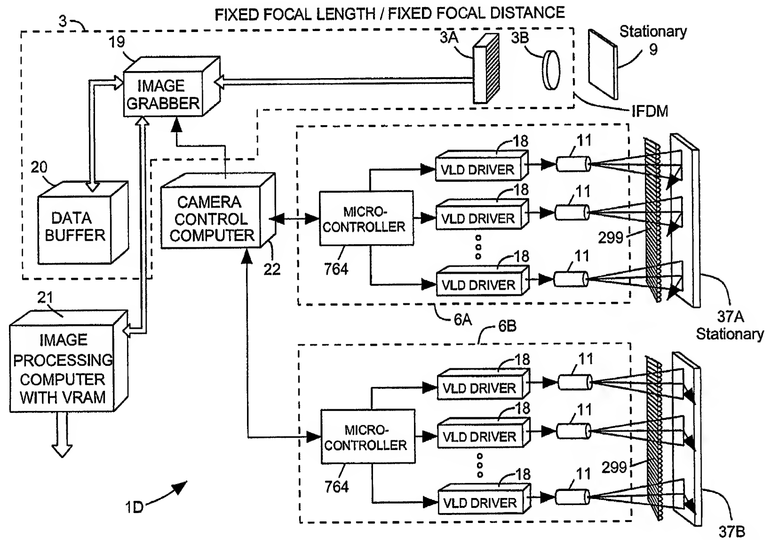

FIXED FOCAL LENGTH / FIXED FOCAL DISTANCE
3
19
IMAGE GRABBER
3A
3B
Stationary
9
IFDM
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
VLD DRIVER
18
11
299
37A
Stationary
6A
6B
21
IMAGE PROCESSING COMPUTER WITH VRAM
1D
37B
Stationary

FIG. 1S2

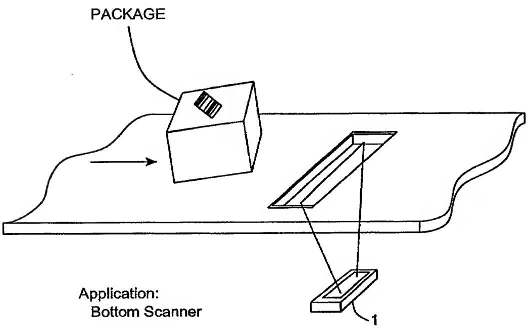


FIG. 1T

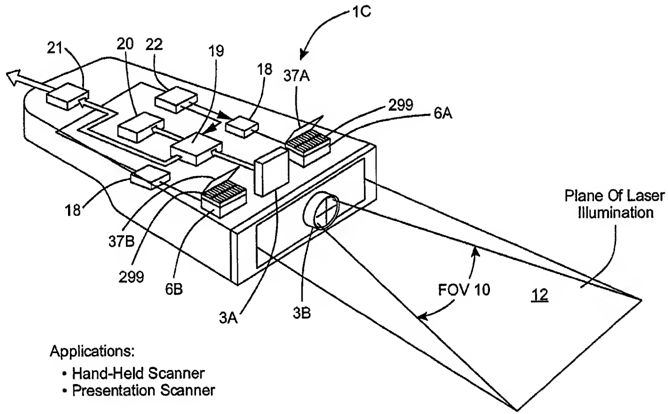

1C
21
20
22
19
18
37A
299
6A
18
37B
299
6B
3A
3B
FOV 10
12
Plane Of Laser
Illumination
Applications:
• Hand-Held Scanner
• Presentation Scanner

FIG. 1U

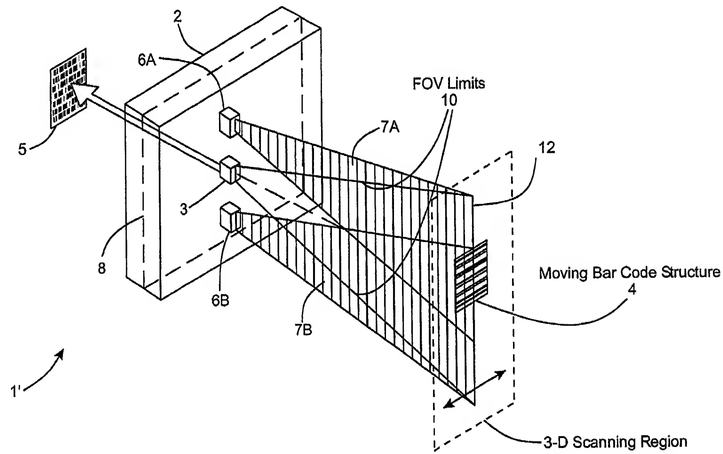

2
6A
5
FOV Limits
10
7A
12
3
8
6B
7B
Moving Bar Code Structure
4
1'
3-D Scanning Region

FIG. 1V1

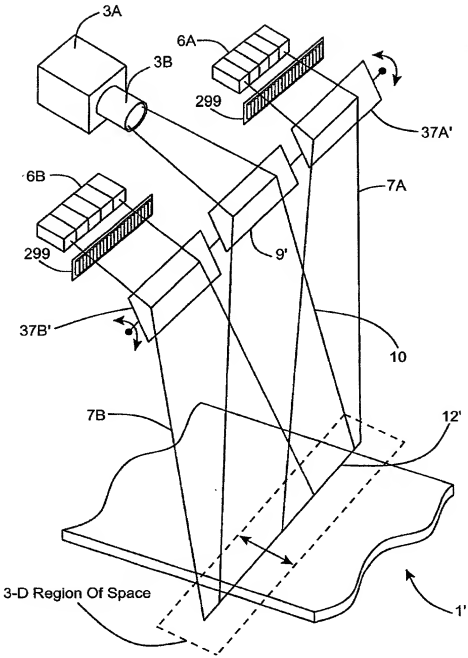


FIG. 1V2

10052040.010502

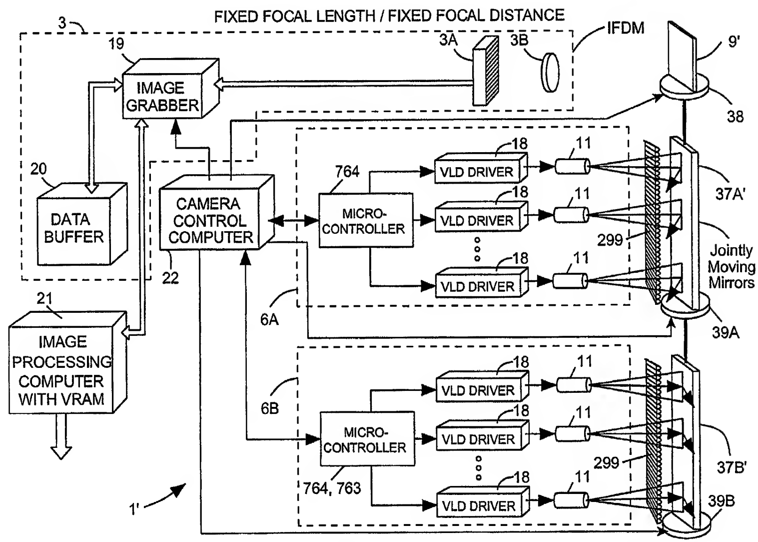

FIXED FOCAL LENGTH / FIXED FOCAL DISTANCE
3
19
IMAGE GRABBER
3A
3B
IFDM
9'
38
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
764
MICRO-CONTROLLER
VLD DRIVER
18
11
299
37A'
Jointly Moving Mirrors
39A
6A
21
IMAGE PROCESSING COMPUTER WITH VRAM
6B
764, 763
37B'
39B
1'

FIG. 1V3

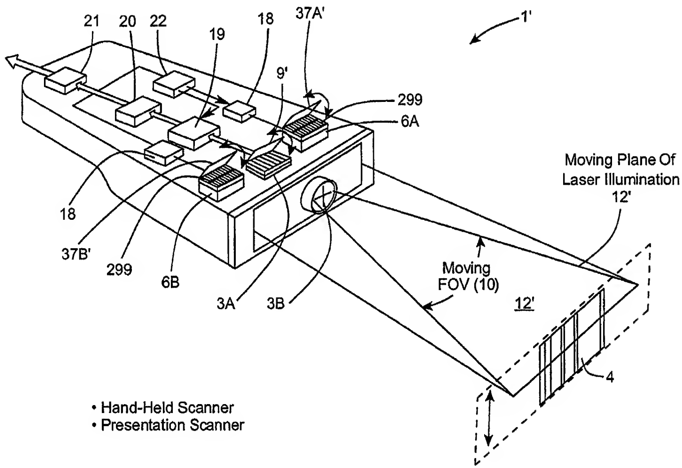

1'
21
20
22
19
18
37A'
9'
299
6A
18
37B'
299
6B
3A
3B
Moving Plane Of
Laser Illumination
12'
Moving
FOV (10)
12'
4
• Hand-Held Scanner
• Presentation Scanner

FIG. 1V4

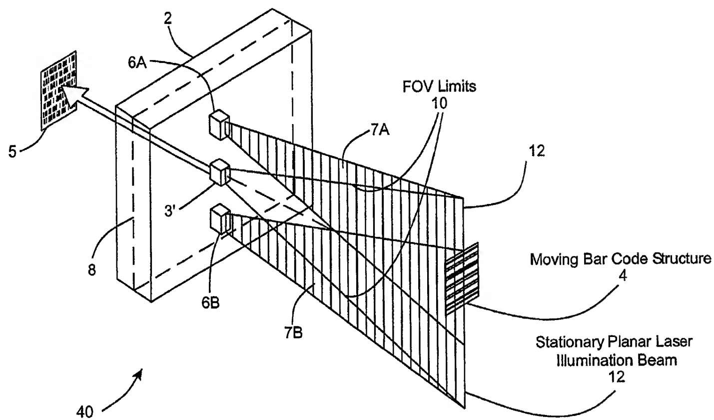

2
6A
5
FOV Limits
10
7A
12
3'
8
6B
7B
Moving Bar Code Structure
4
Stationary Planar Laser
Illumination Beam
12
40

FIG. 2A

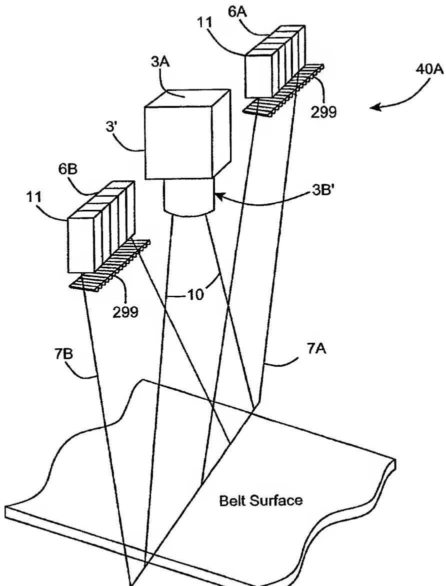


FIG. 2B1

40057516.072002

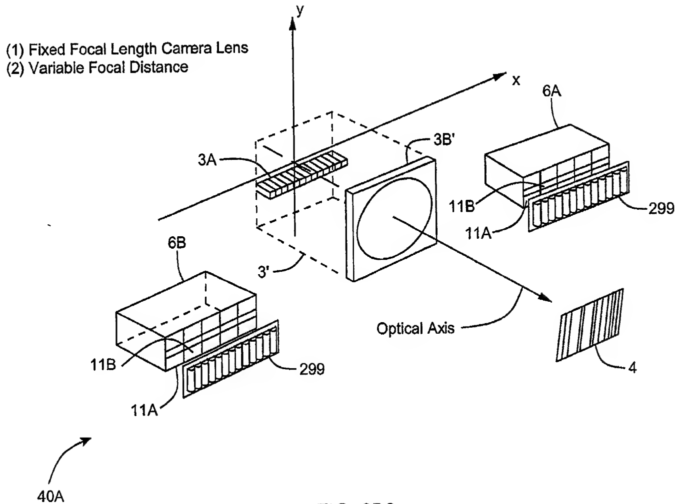

(1) Fixed Focal Length Camera Lens
(2) Variable Focal Distance
y
x
3A
3B'
6A
11B
11A
299
6B
3'
Optical Axis
4
11B
299
11A
40A

FIG. 2B2

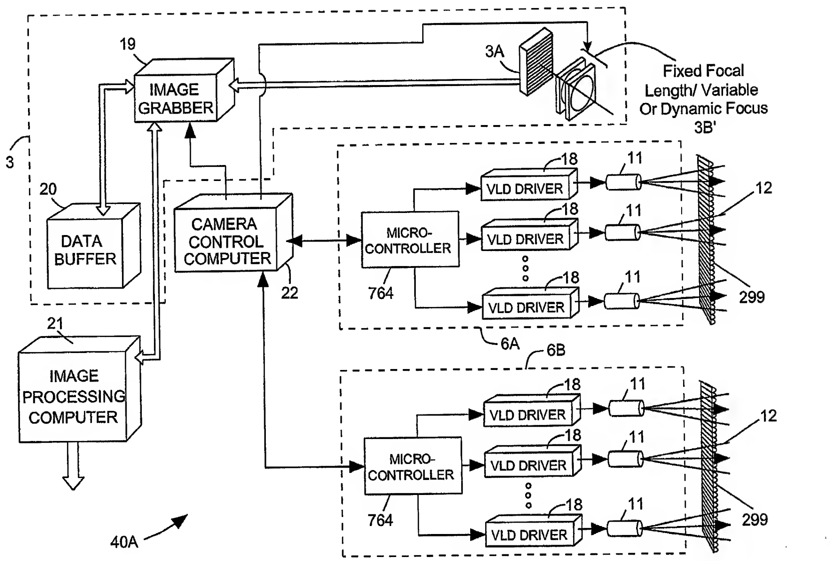


IMAGE GRABBER
19
3A
Fixed Focal Length/ Variable Or Dynamic Focus 3B'
3
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
VLD DRIVER
18
11
12
299
6A
6B
21
IMAGE PROCESSING COMPUTER
40A

FIG. 2C1

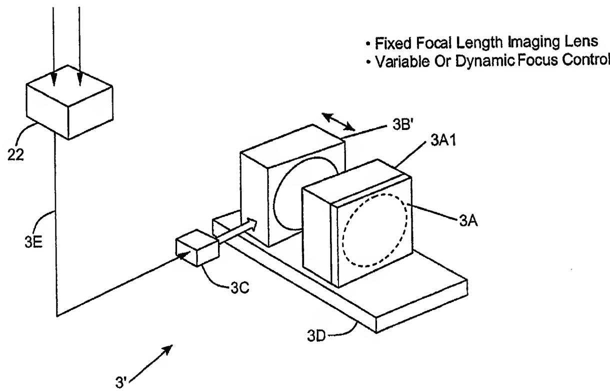

• Fixed Focal Length Imaging Lens
• Variable Or Dynamic Focus Control
3B'
3A1
3A
22
3E
3C
3D
3'

FIG. 2C2

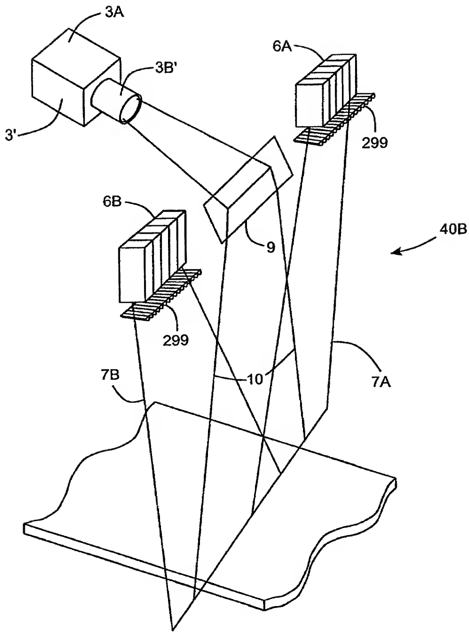
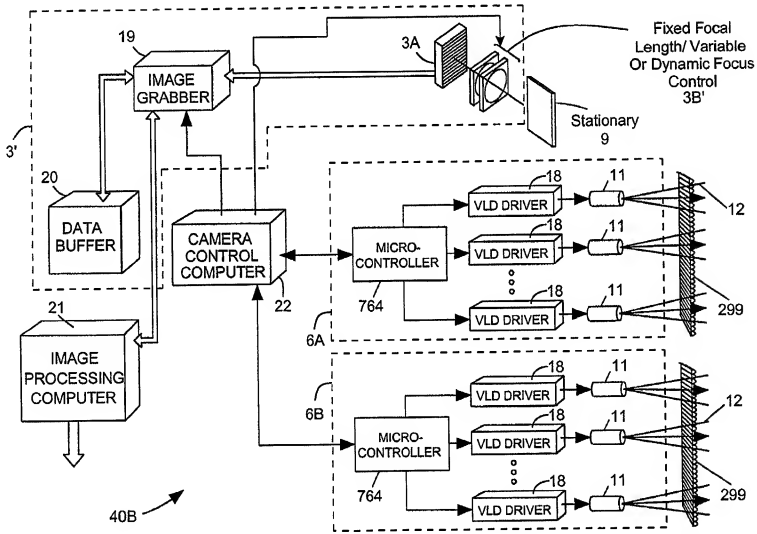


FIG. 2D1



Fixed Focal Length/ Variable Or Dynamic Focus Control 3B'
3A
19
IMAGE GRABBER
Stationary 9
3'
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
21
IMAGE PROCESSING COMPUTER
MICRO-CONTROLLER
764
6A
6B
VLD DRIVER
18
11
12
299
40B

FIG. 2D2

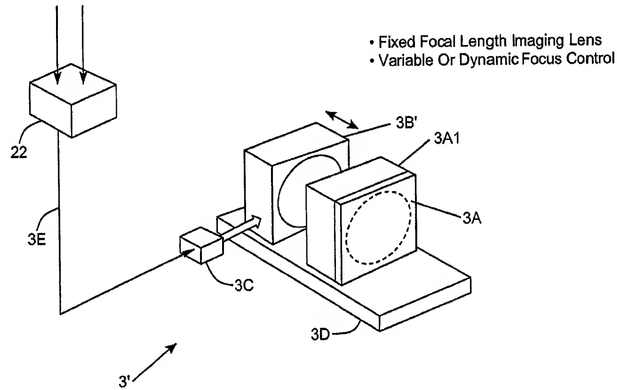

• Fixed Focal Length Imaging Lens
• Variable Or Dynamic Focus Control
3B'
3A1
3A
22
3E
3C
3D
3'

FIG. 2D3

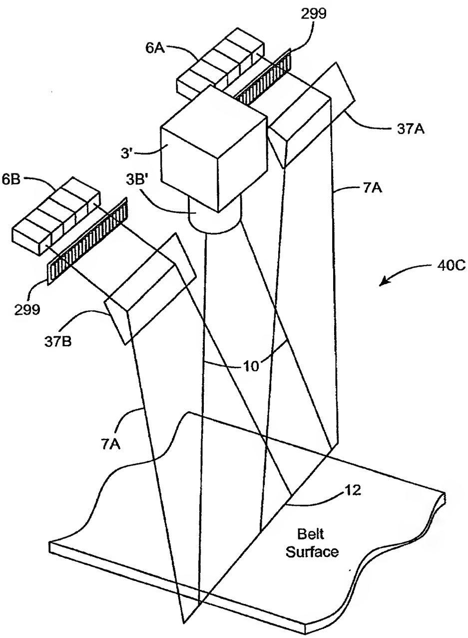


FIG. 2E1

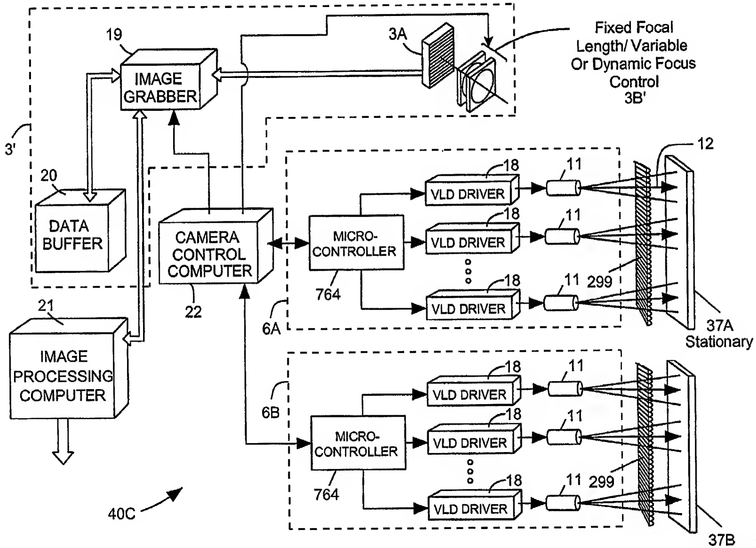
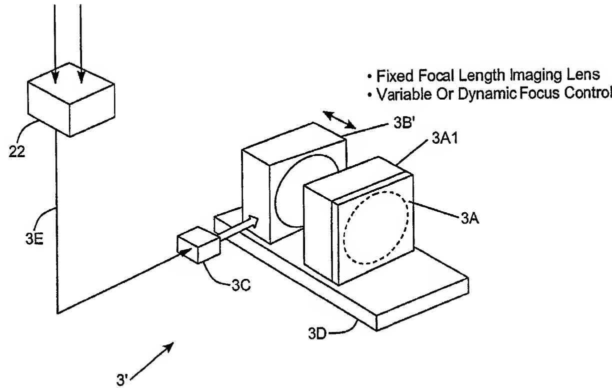

19
IMAGE GRABBER
3A
Fixed Focal Length/ Variable Or Dynamic Focus Control 3B'
3'
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
21
IMAGE PROCESSING COMPUTER
12
18
11
VLD DRIVER
MICRO-CONTROLLER
764
299
6A
37A Stationary
6B
37B Stationary
40C

FIG. 2E2



• Fixed Focal Length Imaging Lens
• Variable Or Dynamic Focus Control
3B'
3A1
3A
22
3E
3C
3D
3'

FIG. 2E3

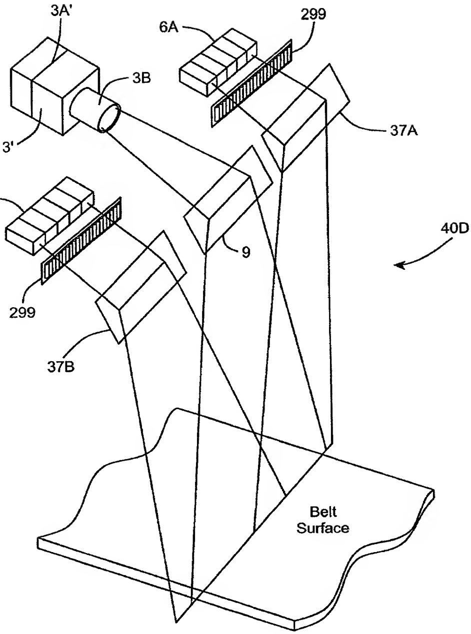


FIG. 2F1

20060207.045200T

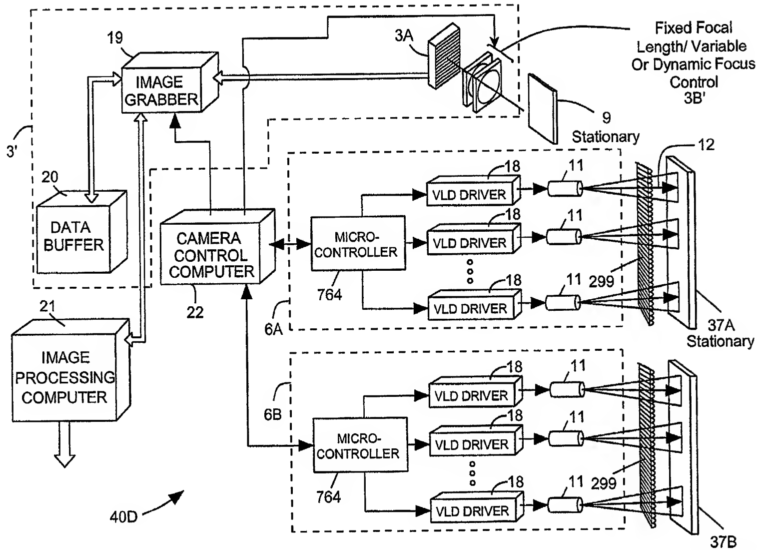


FIG. 2F2

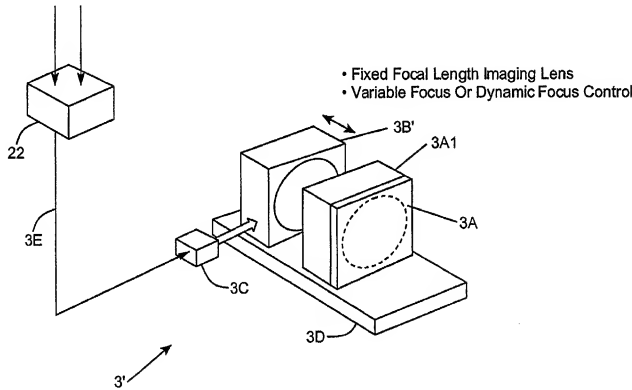

• Fixed Focal Length Imaging Lens
• Variable Focus Or Dynamic Focus Control
22
3E
3C
3D
3'
3B'
3A1
3A

FIG. 2F3

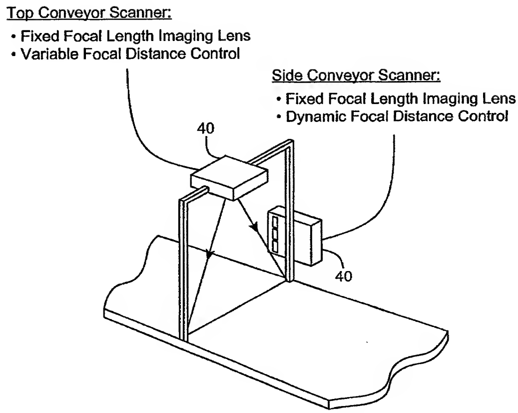

Top Conveyor Scanner:
• Fixed Focal Length Imaging Lens
• Variable Focal Distance Control
Side Conveyor Scanner:
• Fixed Focal Length Imaging Lens
• Dynamic Focal Distance Control
40
40

FIG. 2G

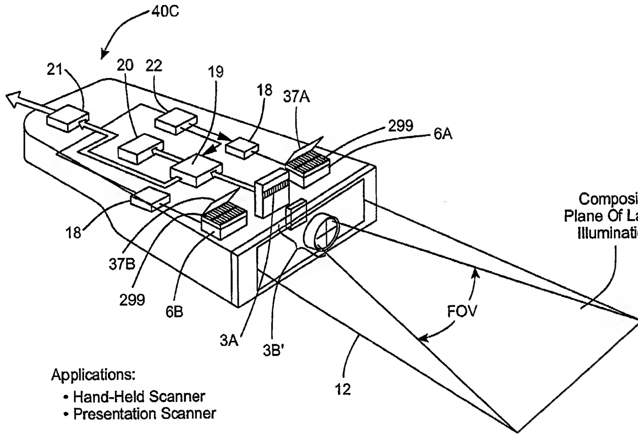

40C
21
20
22
19
18
37A
299
6A
Composite
Plane Of Laser
Illumination
18
37B
299
6B
3A
3B'
FOV
12
Applications:
• Hand-Held Scanner
• Presentation Scanner

FIG. 2H

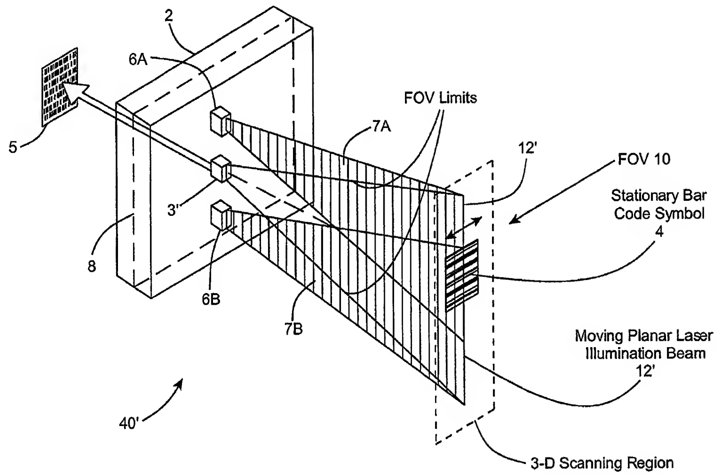

2
6A
5
FOV Limits
7A
12'
FOV 10
Stationary Bar
Code Symbol
4
3'
8
6B
7B
Moving Planar Laser
Illumination Beam
12'
40'
3-D Scanning Region

FIG. 2I1

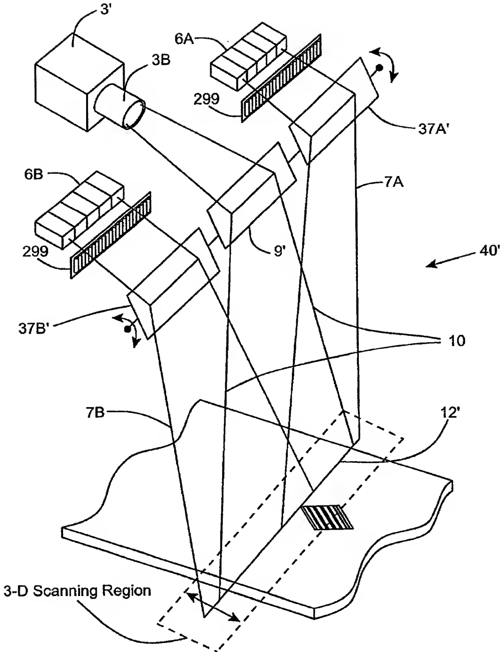


FIG. 2I2

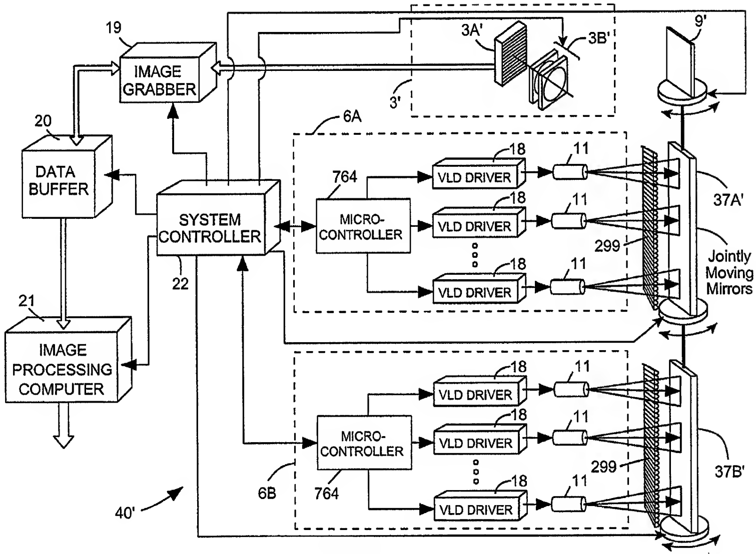

19
IMAGE GRABBER
20
DATA BUFFER
21
IMAGE PROCESSING COMPUTER
SYSTEM CONTROLLER
22
3A'
3B'
3'
9'
6A
764
MICRO-CONTROLLER
VLD DRIVER
18
11
299
37A'
Jointly Moving Mirrors
6B
37B'
40'

FIG. 2I3

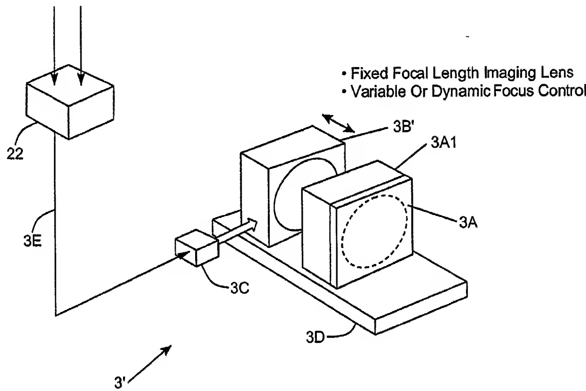

• Fixed Focal Length Imaging Lens
• Variable Or Dynamic Focus Control
3B'
3A1
3A
22
3E
3C
3D
3'

FIG. 2I4

20060201 0452907

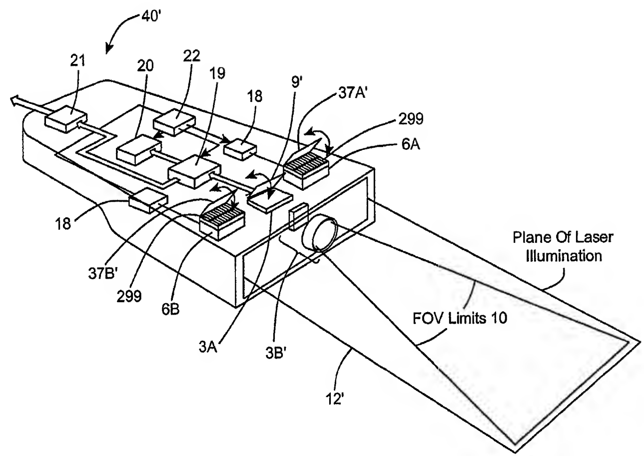


FIG. 2I5

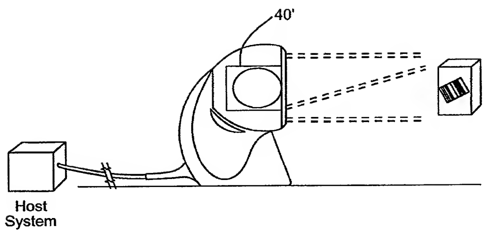


FIG. 216

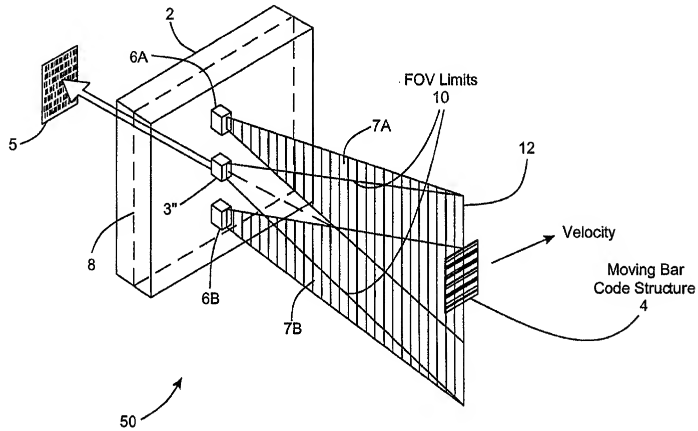

2
6A
5
FOV Limits
10
7A
12
3"
Velocity
8
Moving Bar
Code Structure
4
6B
7B
50

FIG. 3A

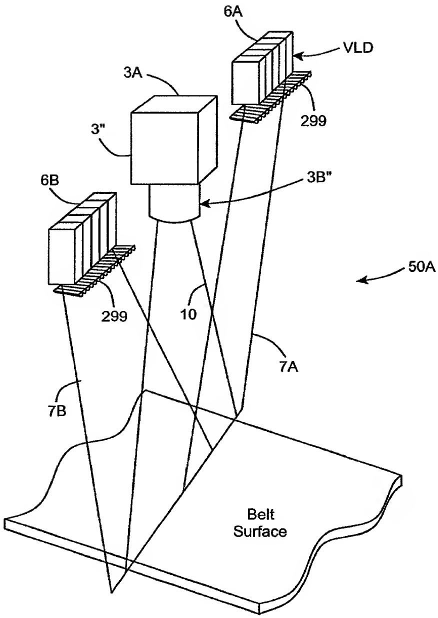


FIG. 3B1

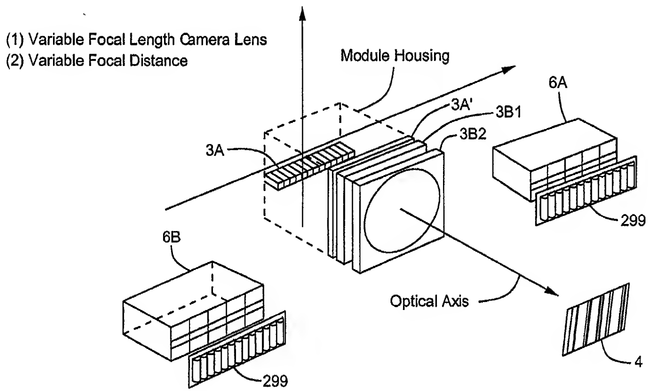
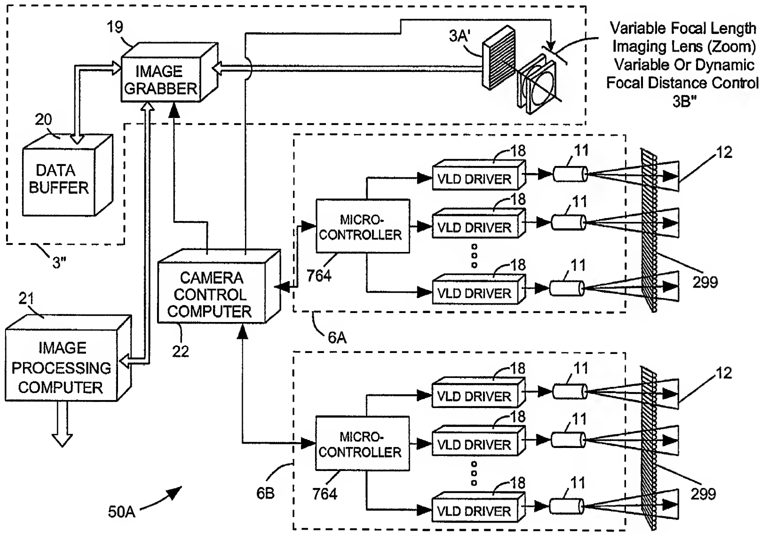

(1) Variable Focal Length Camera Lens
(2) Variable Focal Distance
Module Housing
6A
3A'
3B1
3B2
3A
299
6B
Optical Axis
299
4

FIG. 3B2



19
IMAGE GRABBER
20
DATA BUFFER
3"
3A'
Variable Focal Length Imaging Lens (Zoom) Variable Or Dynamic Focal Distance Control 3B"
21
IMAGE PROCESSING COMPUTER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
VLD DRIVER
18
11
12
299
6A
6B
50A

FIG. 3C1

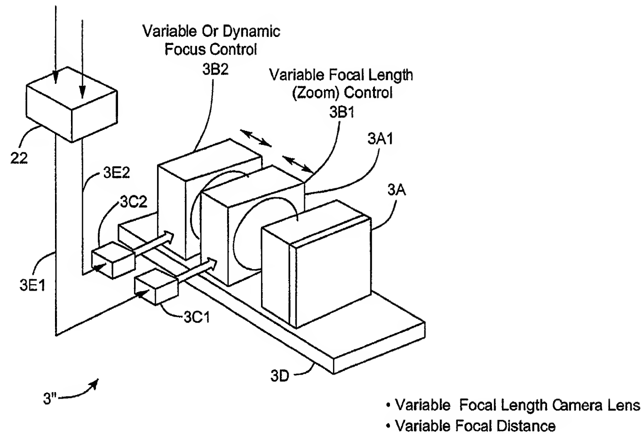

Variable Or Dynamic
Focus Control
3B2
Variable Focal Length
(Zoom) Control
3B1
3A1
3A
22
3E2
3C2
3E1
3C1
3D
3"
• Variable Focal Length Camera Lens
• Variable Focal Distance

FIG. 3C2

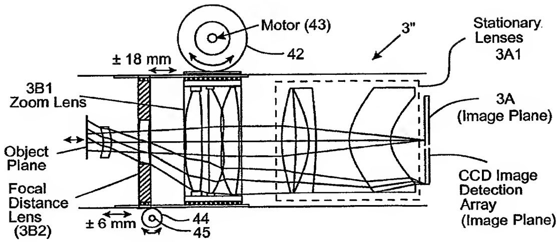


FIG. 3D1

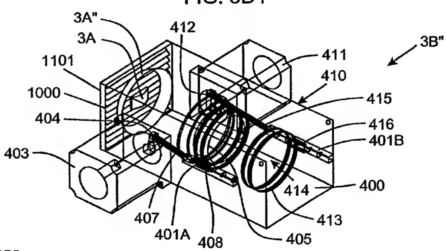


FIG. 3D2

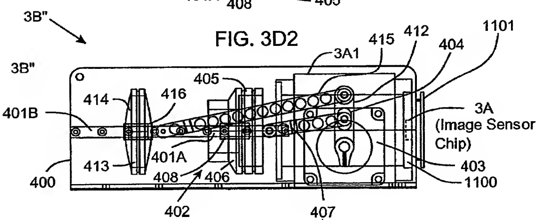


FIG. 3D3

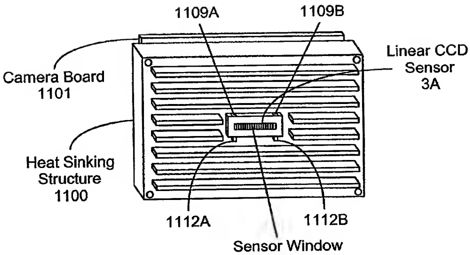


FIG. 3D4

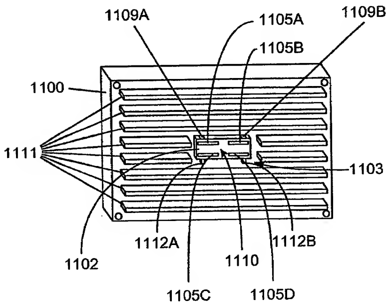


FIG. 3D5

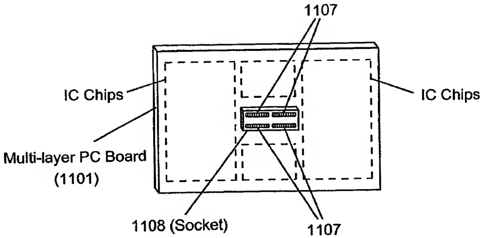


FIG. 3D6

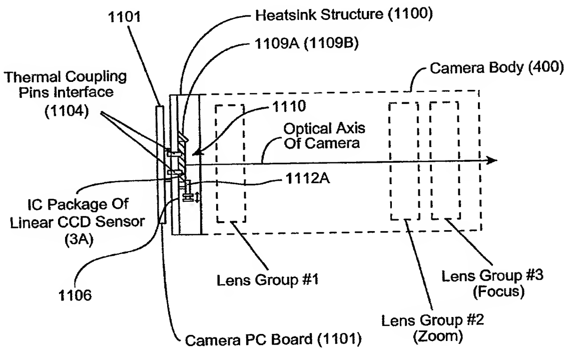


FIG. 3D7

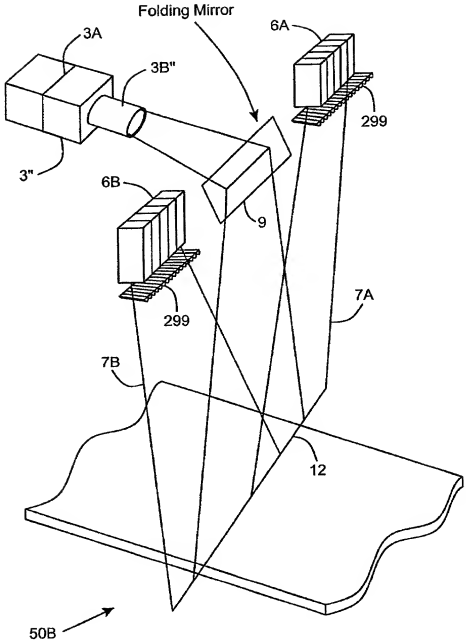
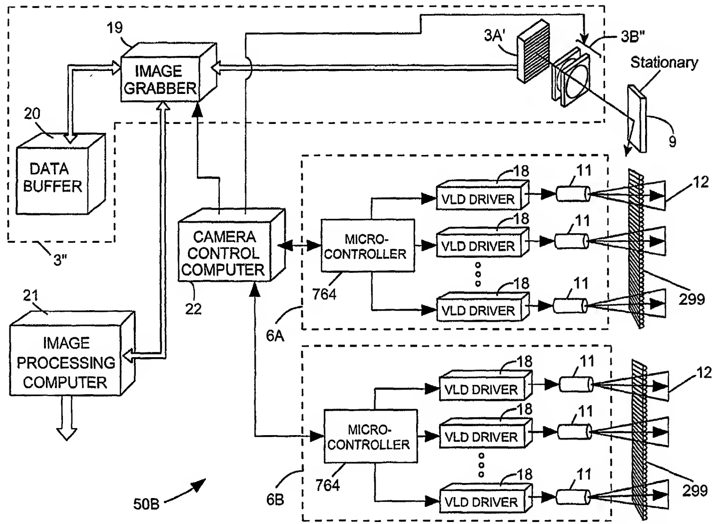


FIG. 3E1



19
IMAGE GRABBER
20
DATA BUFFER
3"
21
IMAGE PROCESSING COMPUTER
CAMERA CONTROL COMPUTER
22
3A'
3B"
Stationary
9
MICRO-CONTROLLER
764
6A
6B
VLD DRIVER
18
11
12
299
50B

FIG. 3E2

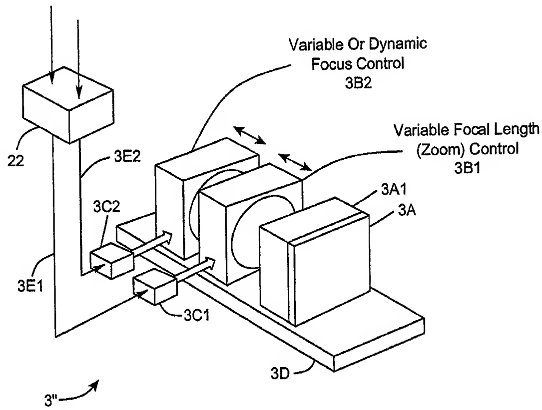

Variable Or Dynamic
Focus Control
3B2
Variable Focal Length
(Zoom) Control
3B1
3A1
3A
22
3E2
3C2
3E1
3C1
3D
3"

FIG. 3E3

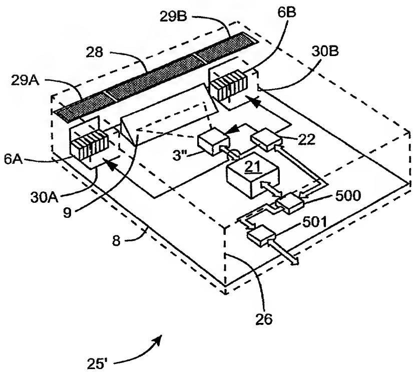
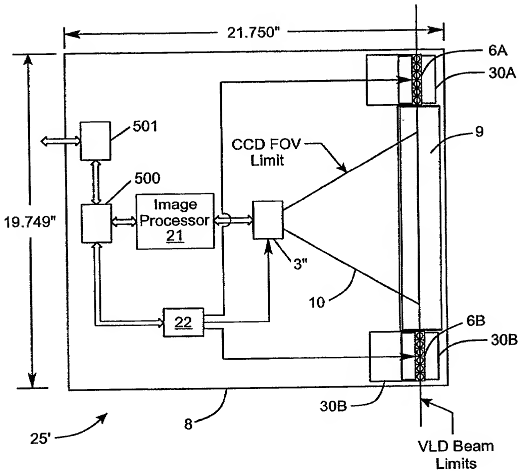


FIG. 3E4



21.750"
6A
30A
501
9
CCD FOV
Limit
500
Image
Processor
21
19.749"
3"
10
22
6B
30B
30B
8
25'
VLD Beam
Limits

FIG. 3E5

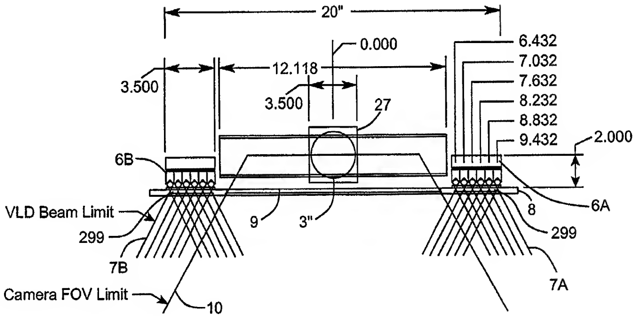

20"
0.000
12.118
3.500
3.500
27
6.432
7.032
7.632
8.232
8.832
9.432
2.000
6B
6A
8
9
3"
VLD Beam Limit
299
299
7B
7A
Camera FOV Limit
10

FIG. 3E6

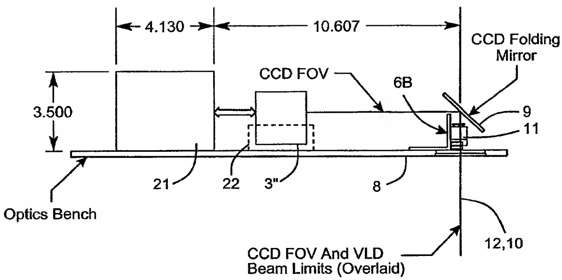

4.130
10.607
CCD Folding
Mirror
CCD FOV
6B
3.500
9
11
21
22
3"
8
Optics Bench
12,10
CCD FOV And VLD
Beam Limits (Overlaid)

FIG. 3E7

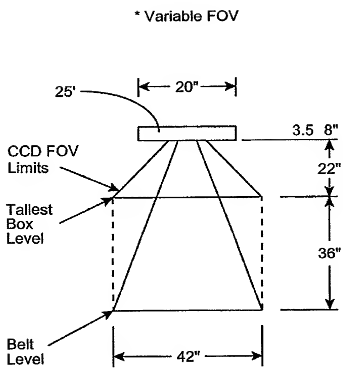

* Variable FOV
25'
20"
3.5 8"
CCD FOV Limits
22"
Tallest Box Level
36"
Belt Level
42"

FIG. 3E8

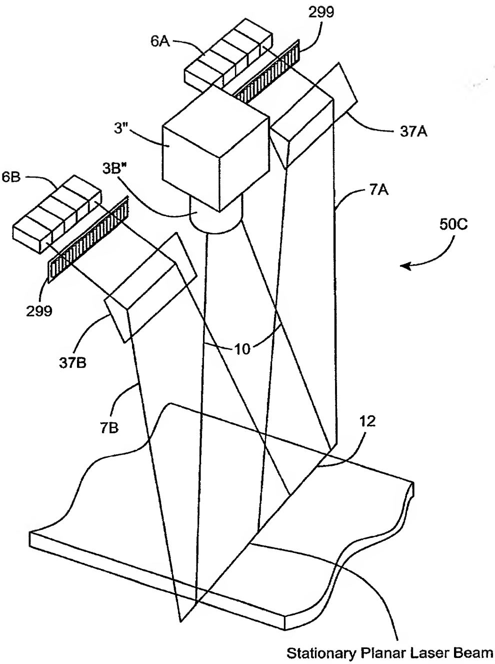

299
6A
3"
37A
6B
3B"
7A
50C
299
10
37B
7B
12
Stationary Planar Laser Beam

FIG. 3F1

2060Z0'0HS2900T

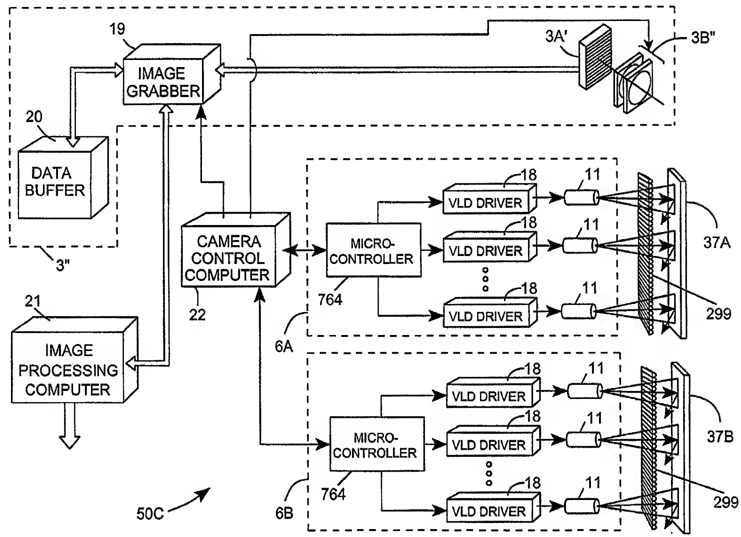


FIG. 3F2

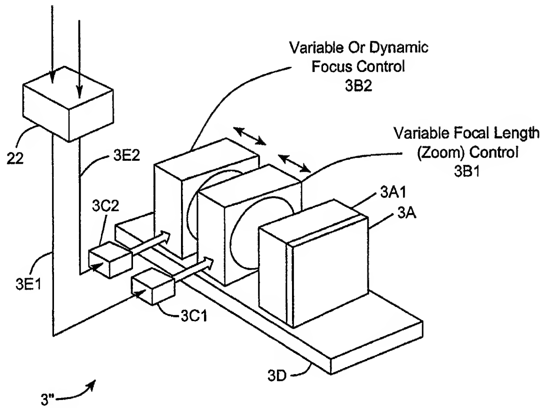

Variable Or Dynamic
Focus Control
3B2
Variable Focal Length
(Zoom) Control
3B1
22
3E2
3C2
3A1
3A
3E1
3C1
3D
3"

FIG. 3F3

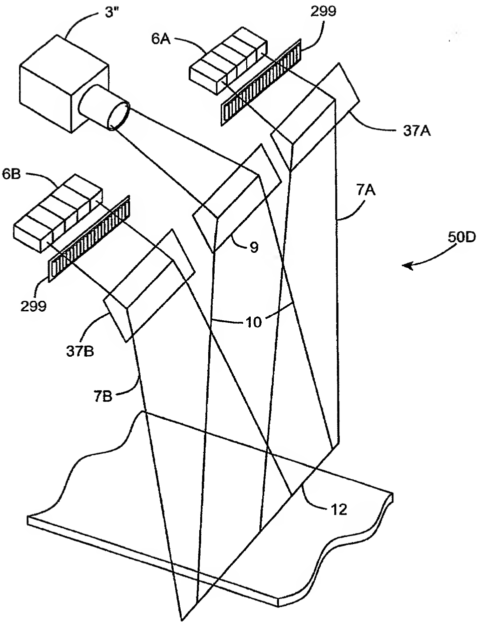
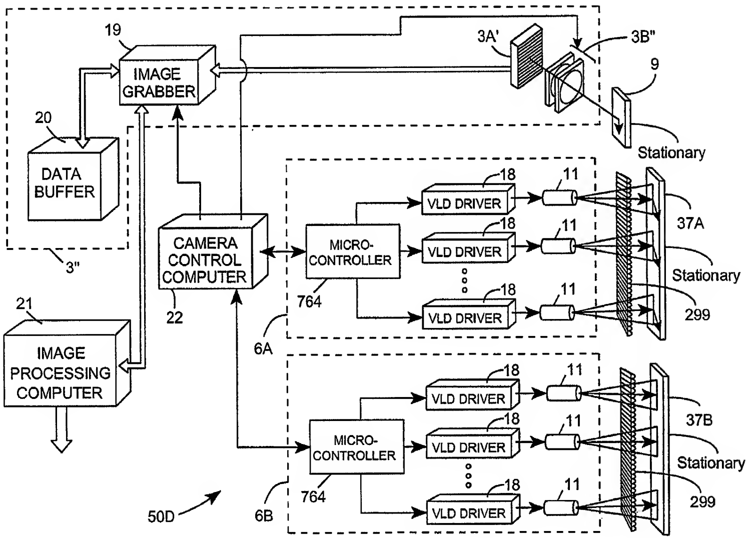


FIG. 3G1



19
IMAGE GRABBER
20
DATA BUFFER
3"
21
IMAGE PROCESSING COMPUTER
CAMERA CONTROL COMPUTER
22
3A'
3B"
9
Stationary
MICRO-CONTROLLER
764
VLD DRIVER
18
11
37A
Stationary
299
6A
37B
Stationary
299
6B
50D

FIG. 3G2

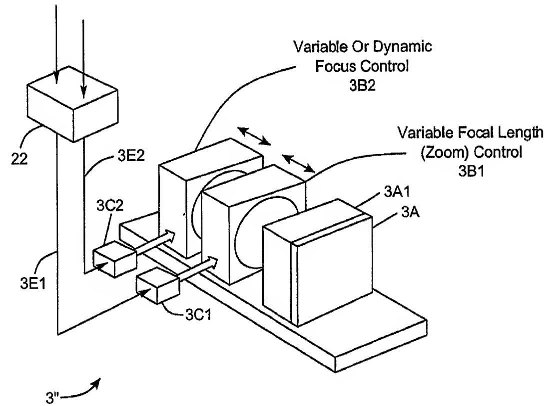

Variable Or Dynamic
Focus Control
3B2
Variable Focal Length
(Zoom) Control
3B1
3A1
3A
22
3E2
3C2
3E1
3C1
3"

FIG. 3G3

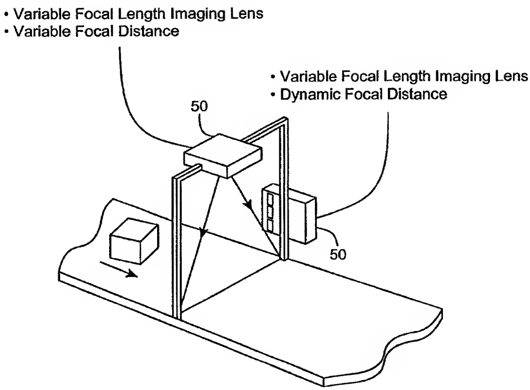

• Variable Focal Length Imaging Lens
• Variable Focal Distance
• Variable Focal Length Imaging Lens
• Dynamic Focal Distance
50
50

FIG. 3H

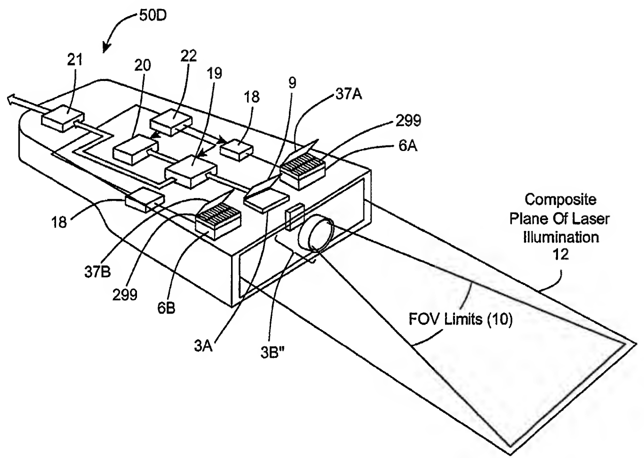

50D
21
20
22
19
18
9
37A
299
6A
18
37B
299
6B
3A
3B"
Composite
Plane Of Laser
Illumination
12
FOV Limits (10)

FIG. 3I

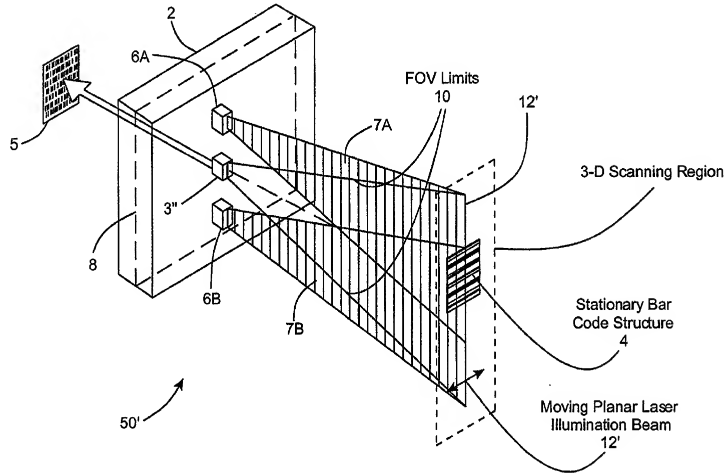
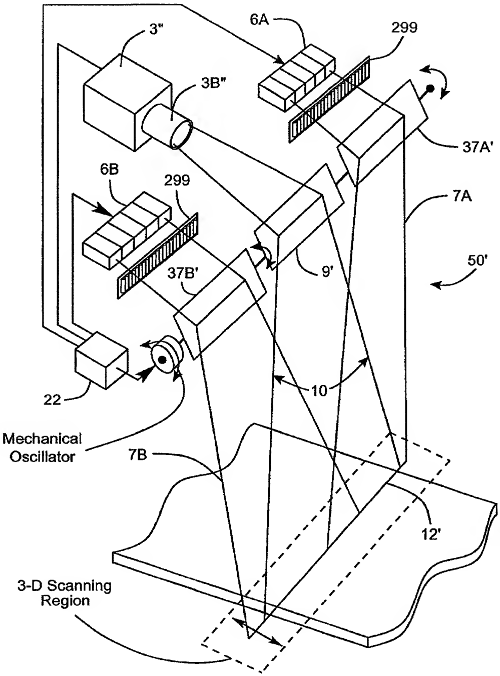

2
6A
FOV Limits
10
12'
7A
5
3-D Scanning Region
3"
8
6B
7B
Stationary Bar
Code Structure
4
Moving Planar Laser
Illumination Beam
12'
50'

FIG. 3J1



3"
6A
299
3B"
37A'
6B
299
7A
37B'
9'
50'
22
10
Mechanical
Oscillator
7B
12'
3-D Scanning
Region

FIG. 3J2

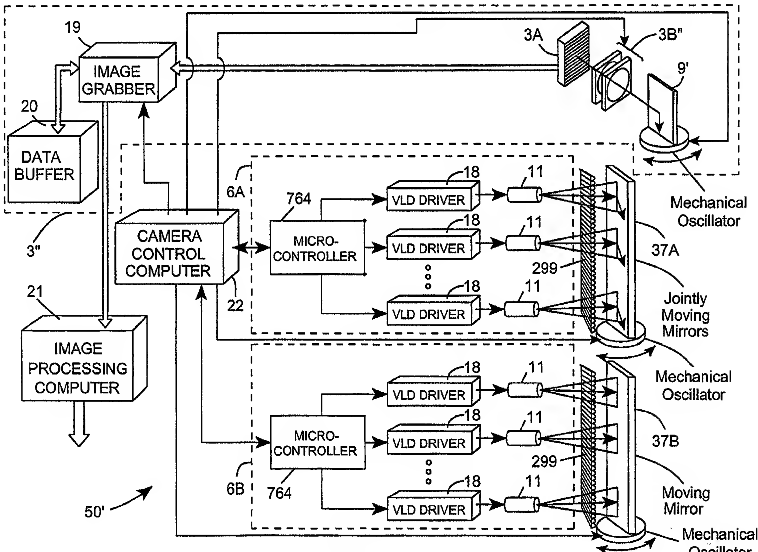
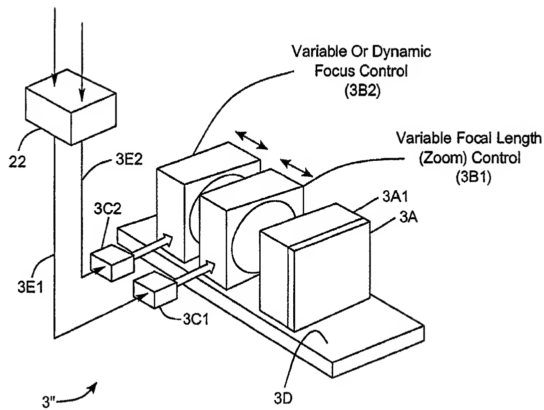


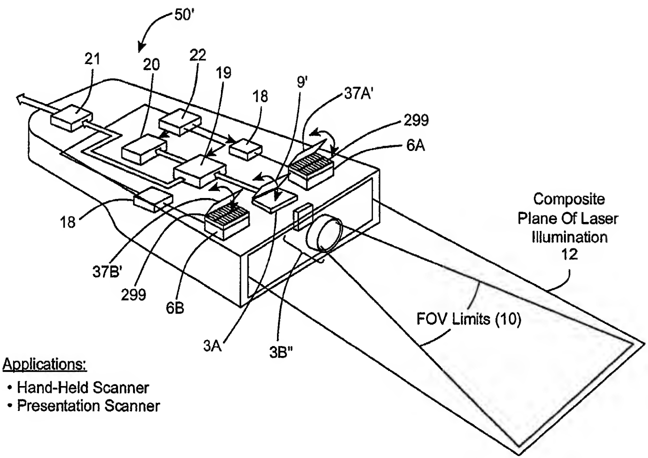
IMAGE GRABBER
DATA BUFFER
CAMERA CONTROL COMPUTER
IMAGE PROCESSING COMPUTER
MICRO-CONTROLLER
VLD DRIVER
Mechanical Oscillator
Jointly Moving Mirrors
Moving Mirror
19
20
21
22
3"
3A
3B"
9'
6A
6B
764
18
11
299
37A
37B
50'

FIG. 3J3



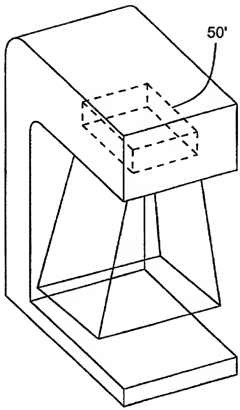
Variable Or Dynamic
Focus Control
(3B2)
Variable Focal Length
(Zoom) Control
(3B1)
22
3E2
3C2
3E1
3C1
3A1
3A
3D
3"

FIG. 3J4



<u>Applications:</u>
- Hand-Held Scanner
- Presentation Scanner

FIG. 3J5



2-D Hold-under Scanner

FIG. 3J6

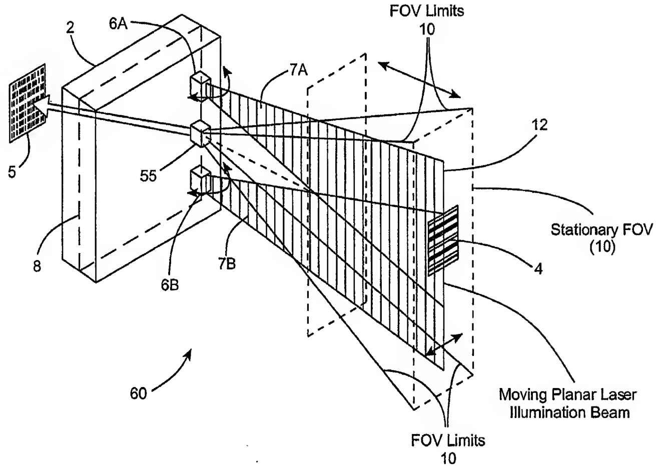

FOV Limits
10
2
6A
7A
5
55
12
Stationary FOV
(10)
8
6B
7B
4
60
Moving Planar Laser
Illumination Beam
FOV Limits
10

FIG. 4A

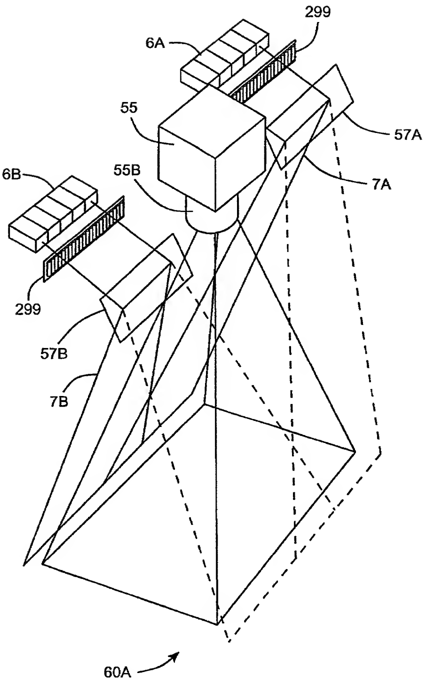


FIG. 4B1

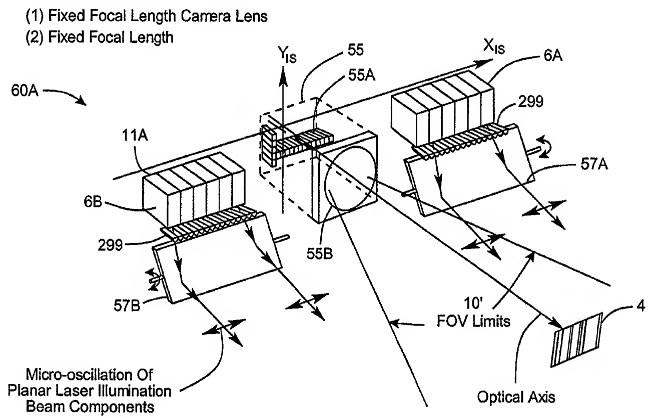
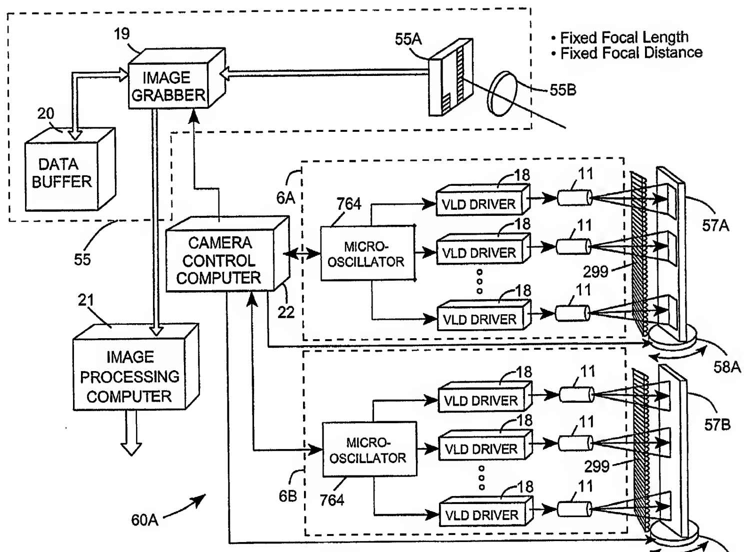
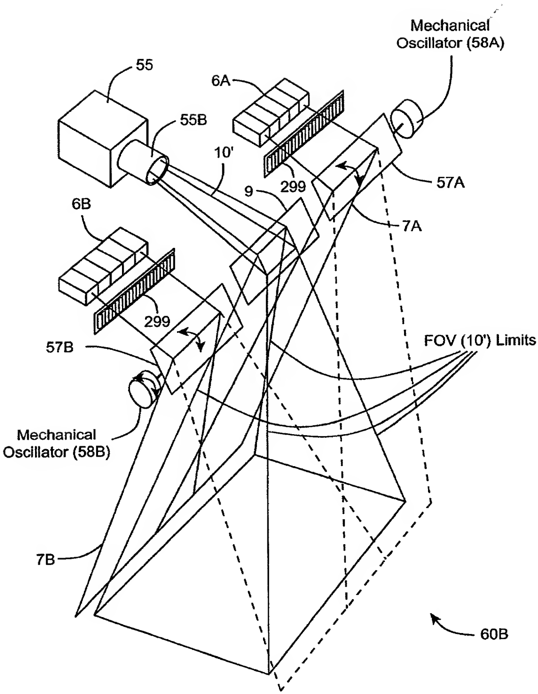

(1) Fixed Focal Length Camera Lens
(2) Fixed Focal Length
60A
11A
6B
299
57B
Y_{IS}
55
55A
55B
X_{IS}
6A
299
57A
10'
FOV Limits
4
Optical Axis
Micro-oscillation Of
Planar Laser Illumination
Beam Components

FIG. 4B2



19
IMAGE GRABBER
20
DATA BUFFER
55A
55B
• Fixed Focal Length
• Fixed Focal Distance
55
CAMERA CONTROL COMPUTER
22
21
IMAGE PROCESSING COMPUTER
6A
764
MICRO-OSCILLATOR
18
VLD DRIVER
11
299
57A
58A
6B
57B
58B
60A

FIG. 4B3



Mechanical
Oscillator (58A)
55
6A
55B
10'
9
299
57A
6B
7A
299
FOV (10') Limits
57B
Mechanical
Oscillator (58B)
7B
60B

FIG. 4C1

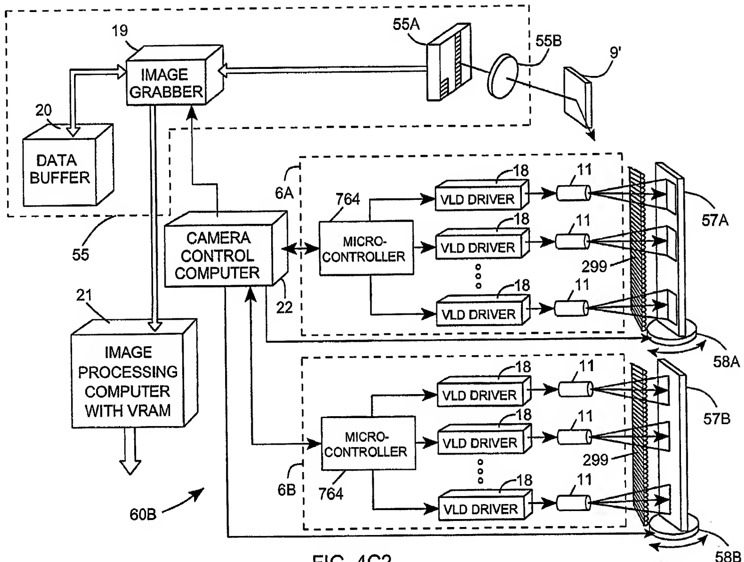
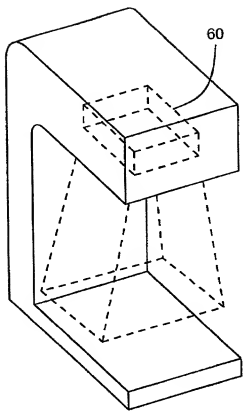


IMAGE GRABBER
DATA BUFFER
CAMERA CONTROL COMPUTER
IMAGE PROCESSING COMPUTER WITH VRAM
MICRO-CONTROLLER
VLD DRIVER
VLD DRIVER
VLD DRIVER
MICRO-CONTROLLER
VLD DRIVER
VLD DRIVER
VLD DRIVER
19
20
21
22
55
55A
55B
9'
6A
6B
764
764
18
11
299
57A
57B
58A
58B
60B

FIG. 4C2



2-D Hold-under Scanner

FIG. 4D

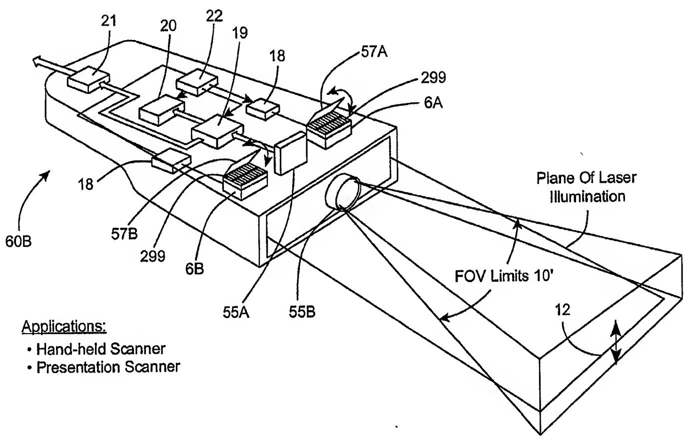

21
20
22
19
18
57A
299
6A
18
60B
57B
299
6B
55A
55B
Plane Of Laser Illumination
FOV Limits 10'
12
Applications:
• Hand-held Scanner
• Presentation Scanner

FIG. 4E

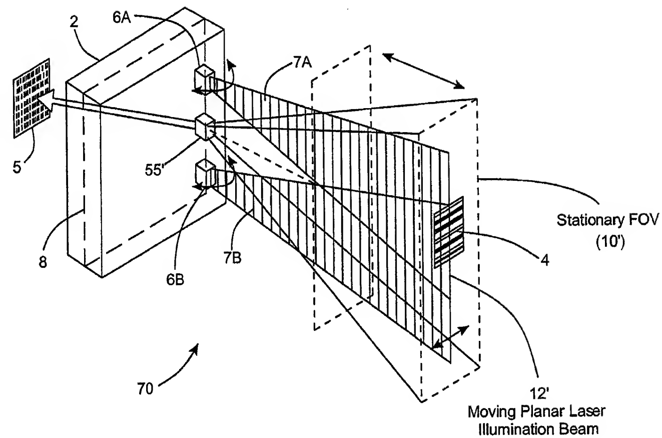

2
6A
7A
5
55'
8
6B
7B
70
Stationary FOV
(10')
4
12'
Moving Planar Laser
Illumination Beam

FIG. 5A

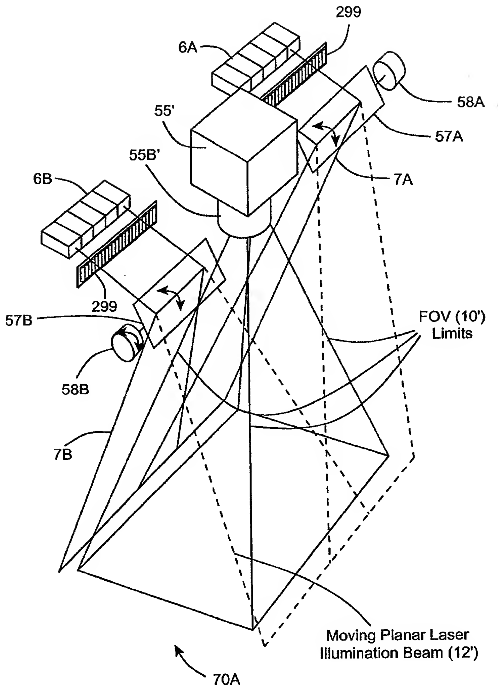

299
6A
58A
55'
57A
55B'
7A
6B
299
57B
FOV (10')
Limits
58B
7B
Moving Planar Laser
Illumination Beam (12')
70A

FIG. 5B1

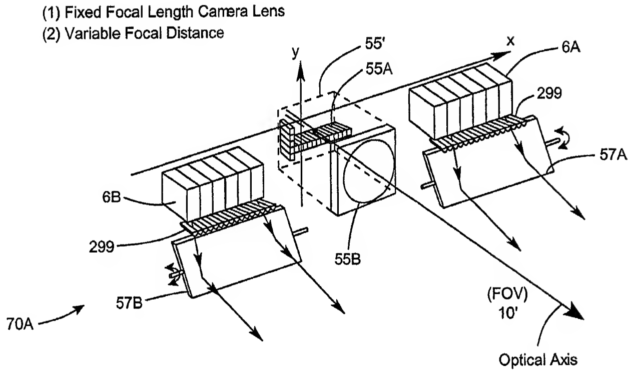

(1) Fixed Focal Length Camera Lens
(2) Variable Focal Distance
y
x
55'
55A
6A
299
57A
6B
299
55B
57B
70A
(FOV)
10'
Optical Axis

FIG. 5B2

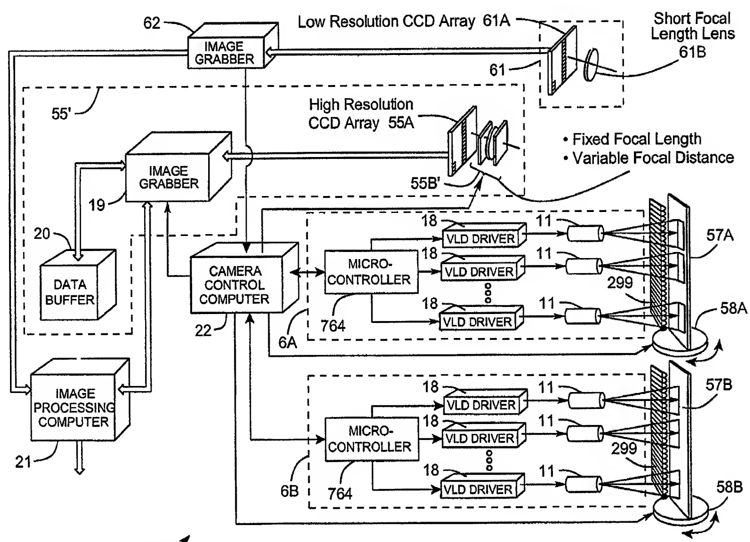

62
IMAGE GRABBER
Low Resolution CCD Array 61A
Short Focal Length Lens 61B
61
55'
High Resolution CCD Array 55A
• Fixed Focal Length
• Variable Focal Distance
55B'
IMAGE GRABBER
19
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
6A
18
VLD DRIVER
11
299
57A
58A
IMAGE PROCESSING COMPUTER
21
MICRO-CONTROLLER
764
6B
57B
58B
70A

FIG. 5B3

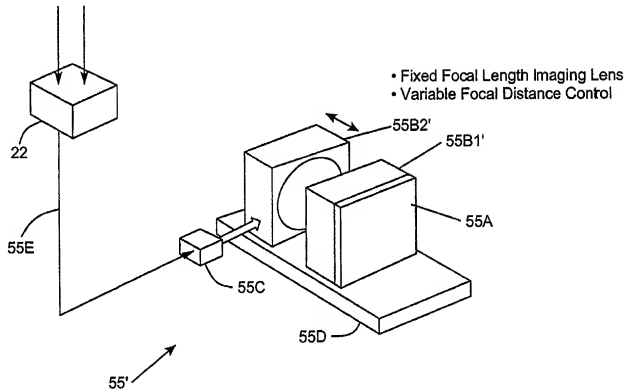

• Fixed Focal Length Imaging Lens
• Variable Focal Distance Control
55B2'
55B1'
55A
22
55E
55C
55D
55'

FIG. 5B4

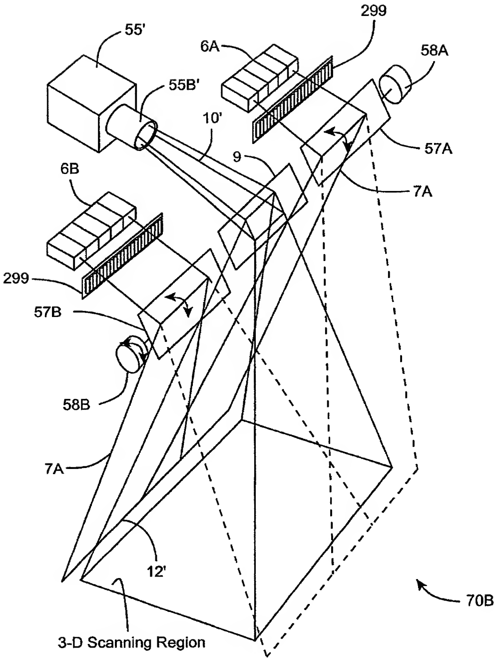

299
55'
6A
58A
55B'
10'
57A
9
6B
7A
299
57B
58B
7A
12'
3-D Scanning Region
70B

FIG. 5C1

(1) Variable Focal Length Camera Lens
(2) Fixed Focal Distance

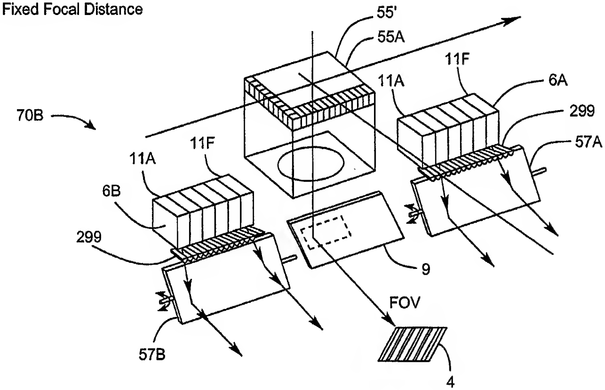
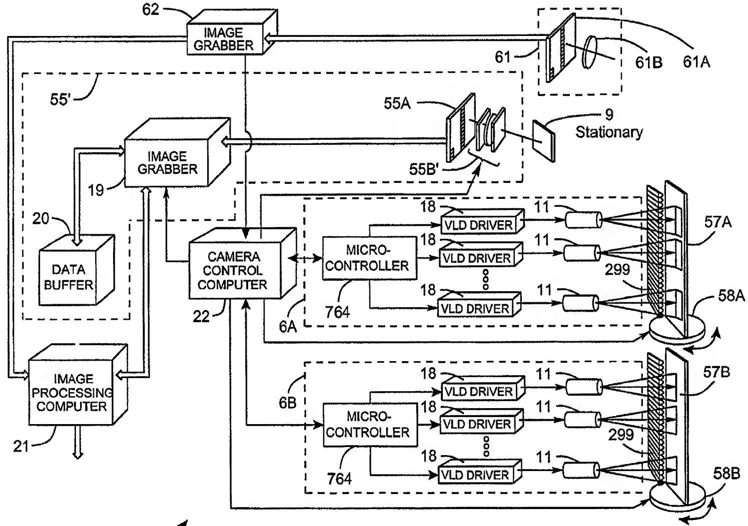


FIG. 5C2



62
IMAGE GRABBER
61
61B
61A
55'
55A
9
Stationary
IMAGE GRABBER
19
55B'
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
18
VLD DRIVER
11
MICRO-CONTROLLER
764
6A
57A
299
58A
6B
57B
58B
IMAGE PROCESSING COMPUTER
21
70B

FIG. 5C3

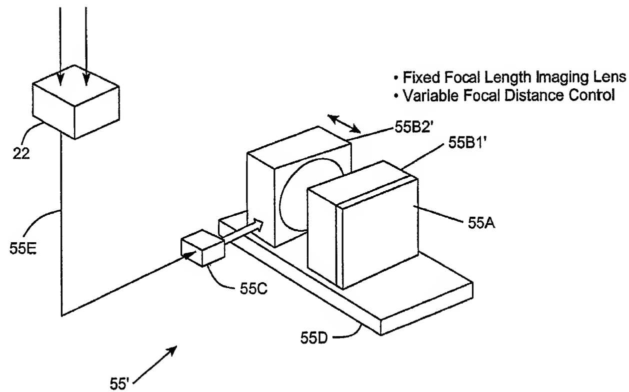

• Fixed Focal Length Imaging Lens
• Variable Focal Distance Control
22
55E
55C
55B2'
55B1'
55A
55D
55'

FIG. 5C4

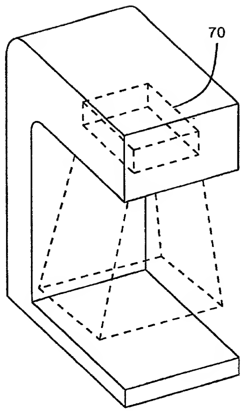


FIG. 5D

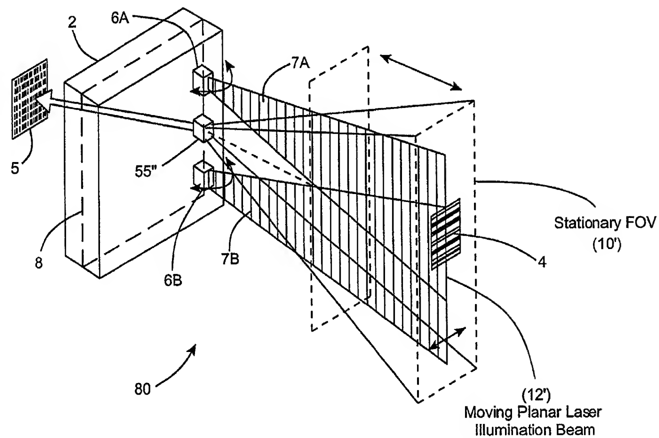

2
6A
7A
5
55"
8
6B
7B
80
Stationary FOV
(10')
4
(12')
Moving Planar Laser
Illumination Beam

FIG. 6A

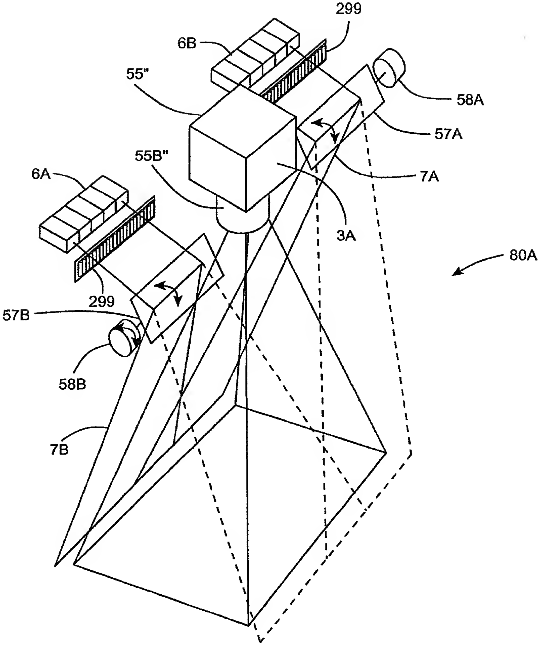


FIG. 6B1

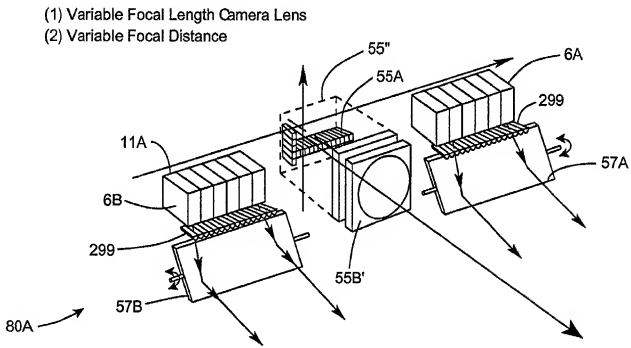

(1) Variable Focal Length Camera Lens
(2) Variable Focal Distance
55"
55A
6A
299
11A
57A
6B
299
55B'
57B
80A

FIG. 6B2

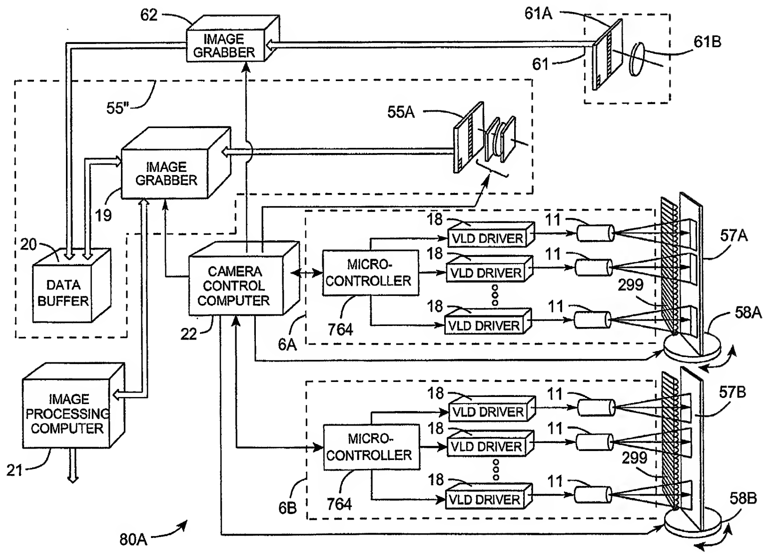
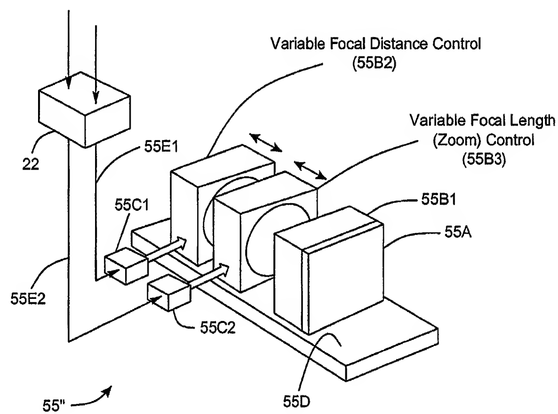

62
IMAGE GRABBER
61A
61B
61
55"
55A
IMAGE GRABBER
19
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
6A
18
VLD DRIVER
11
299
57A
58A
IMAGE PROCESSING COMPUTER
21
6B
57B
58B
80A

FIG. 6B3



Variable Focal Distance Control
(55B2)
Variable Focal Length
(Zoom) Control
(55B3)
55B1
55A
55E1
22
55C1
55E2
55C2
55D
55"

FIG. 6B4

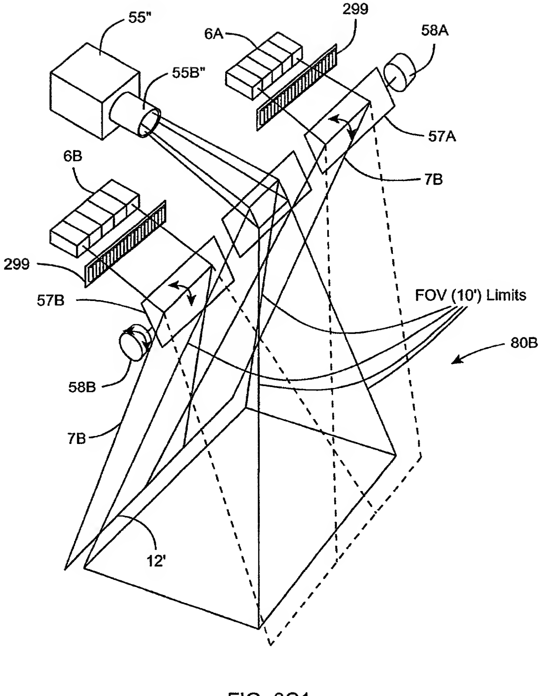


FIG. 6C1

(1) Variable Focal Length Camera Lens
(2) Variable Focal Distance

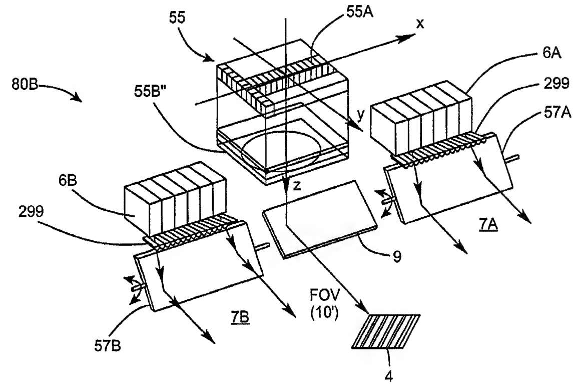
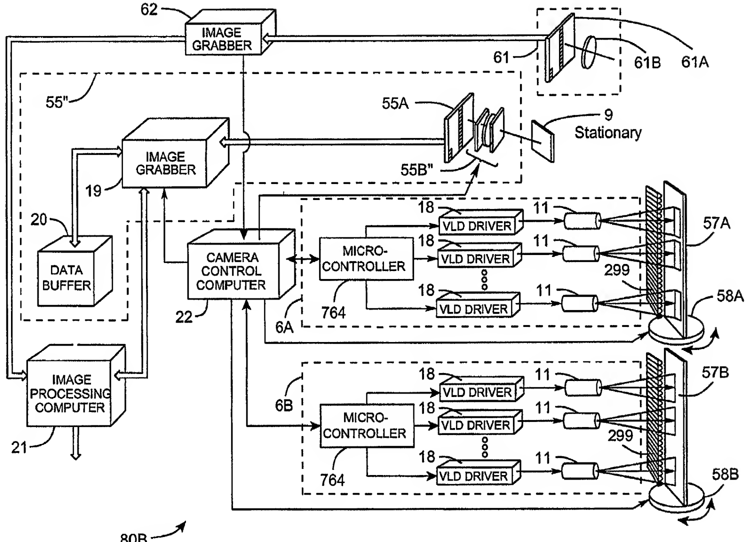


FIG. 6C2



62
IMAGE GRABBER
61
61B
61A
55"
55A
9
Stationary
IMAGE GRABBER
55B"
19
20
DATA BUFFER
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
6A
18
VLD DRIVER
11
299
57A
58A
IMAGE PROCESSING COMPUTER
21
6B
57B
58B
80B

FIG. 6C3

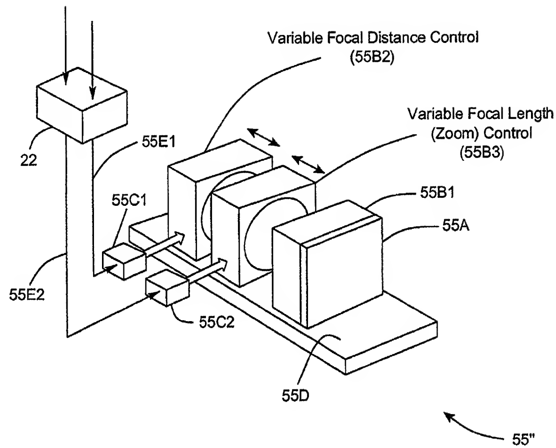

Variable Focal Distance Control
(55B2)
Variable Focal Length
(Zoom) Control
(55B3)
22
55E1
55C1
55B1
55A
55E2
55C2
55D
55"

FIG. 6C4

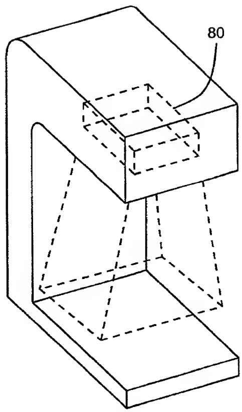


FIG. 6C5

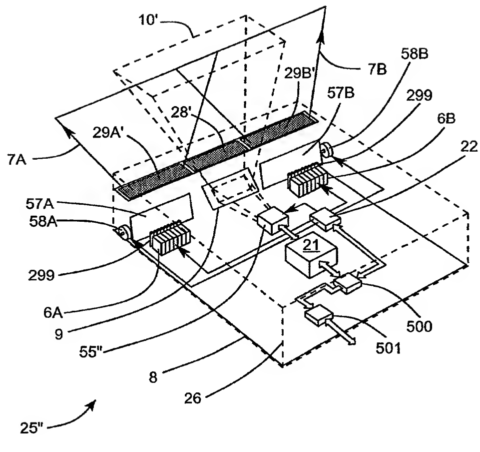

10'
7B
58B
29B'
57B
299
28'
6B
29A'
22
7A
57A
58A
21
299
6A
500
9
501
55"
8
26
25"

FIG. 6D1

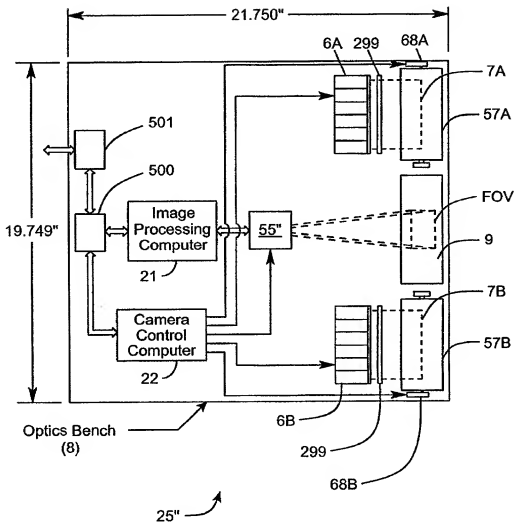

21.750"
6A
299
68A
7A
57A
501
500
19.749"
Image Processing Computer
55"
FOV
9
21
7B
Camera Control Computer
57B
22
Optics Bench (8)
6B
299
68B
25"

FIG. 6D2

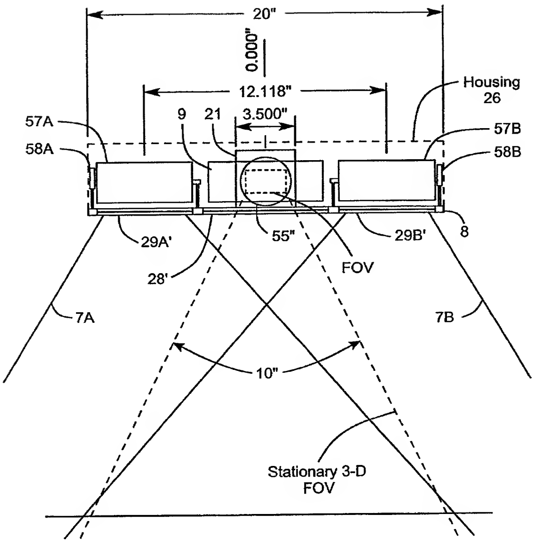

20"
0.000"
12.118"
Housing
26
57A
58A
9
21
3.500"
57B
58B
29A'
28'
55"
FOV
29B'
8
7A
7B
10"
Stationary 3-D
FOV

FIG. 6D3

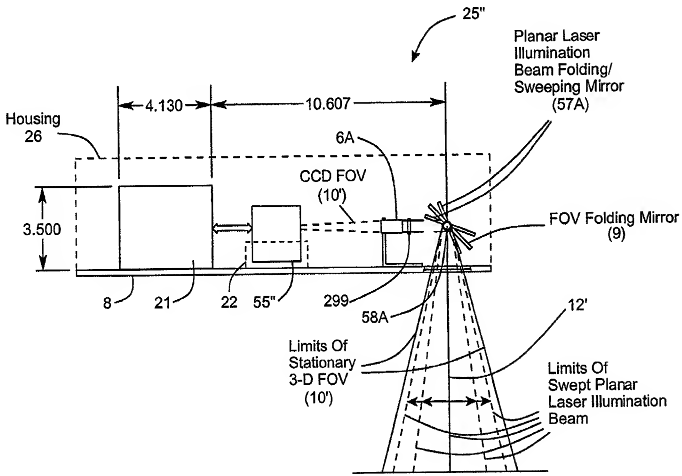

25"
Planar Laser Illumination Beam Folding/ Sweeping Mirror (57A)
4.130
10.607
Housing 26
6A
CCD FOV (10')
3.500
FOV Folding Mirror (9)
8
21
22
55"
299
58A
12'
Limits Of Stationary 3-D FOV (10')
Limits Of Swept Planar Laser Illumination Beam

FIG. 6D4

* Variable FOV

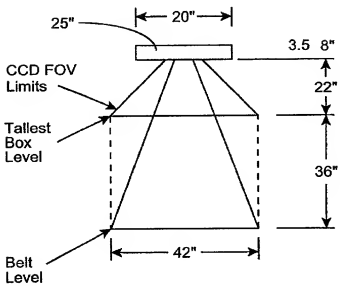


FIG. 6D5

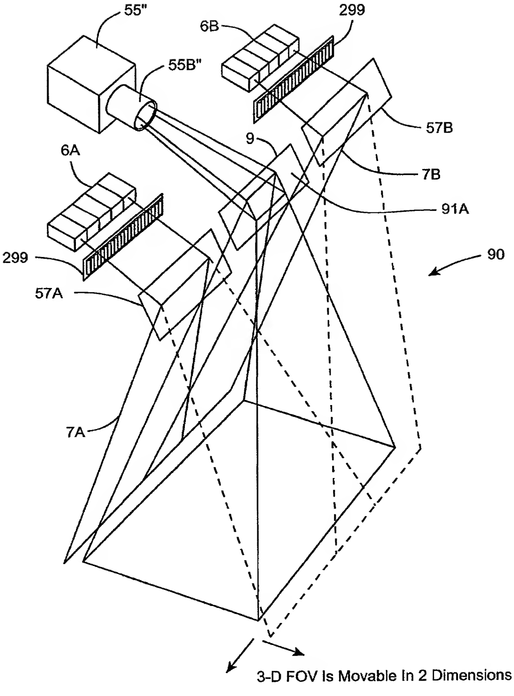

55"
299
6B
55B"
57B
9
6A
7B
91A
299
90
57A
7A
3-D FOV Is Movable In 2 Dimensions

FIG. 6E1

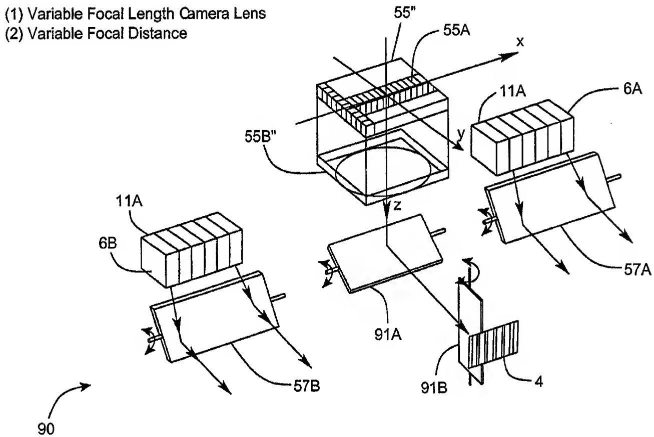
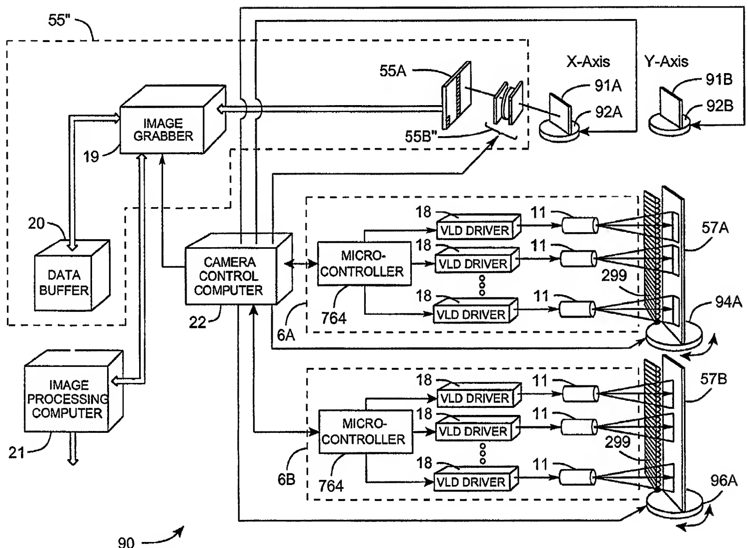

(1) Variable Focal Length Camera Lens
(2) Variable Focal Distance
55"
55A
x
11A
6A
55B"
y
z
11A
6B
57A
91A
91B
4
57B
90

FIG. 6E2



55"
55A
55B"
X-Axis
Y-Axis
91A
92A
91B
92B
IMAGE GRABBER
19
20
DATA BUFFER
IMAGE PROCESSING COMPUTER
21
CAMERA CONTROL COMPUTER
22
MICRO-CONTROLLER
764
6A
6B
18
VLD DRIVER
11
299
57A
94A
57B
96A
90

FIG. 6E3

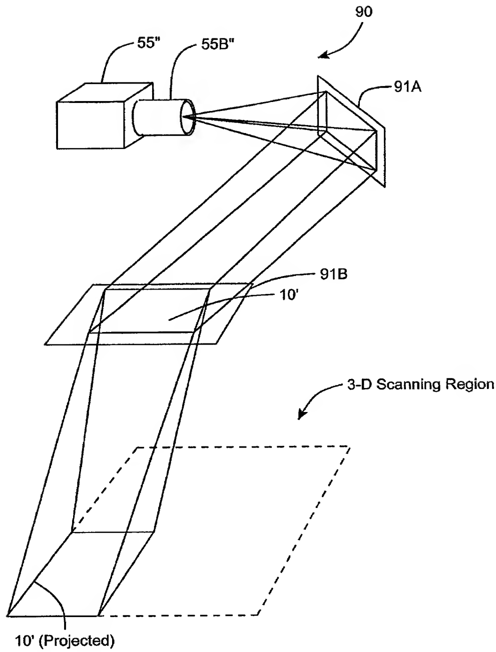


FIG. 6E4

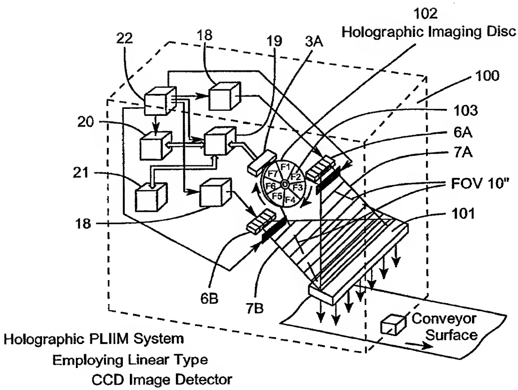

102
Holographic Imaging Disc
22
18
19
3A
100
103
6A
7A
20
21
FOV 10"
101
18
F1
F2
F3
F4
F5
F6
F7
6B
7B
Conveyor
Surface
Holographic PLIIM System
Employing Linear Type
CCD Image Detector

FIG. 7A

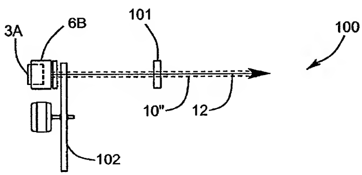

3A
6B
101
100
10"
12
102

FIG. 7B

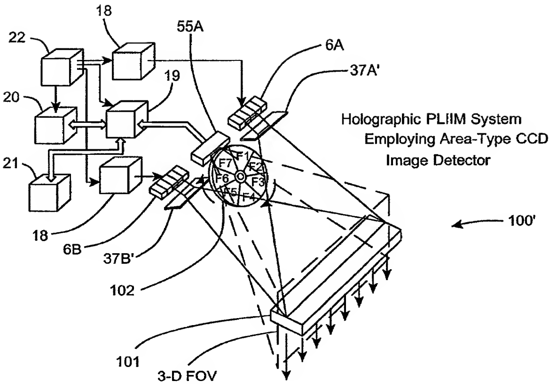

18
55A
22
6A
37A'
19
20
Holographic PLIIM System
Employing Area-Type CCD
Image Detector
21
F1
F2
F3
F4
F5
F6
F7
100'
18
6B
37B'
102
101
3-D FOV

FIG. 8A

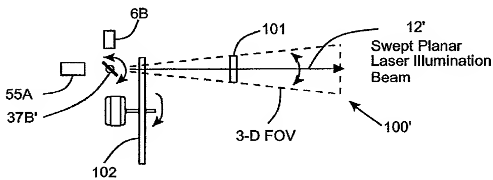

6B
101
12'
Swept Planar
Laser Illumination
Beam
55A
37B'
3-D FOV
100'
102

FIG. 8B

<u>1-D Scanner Embodiment</u>

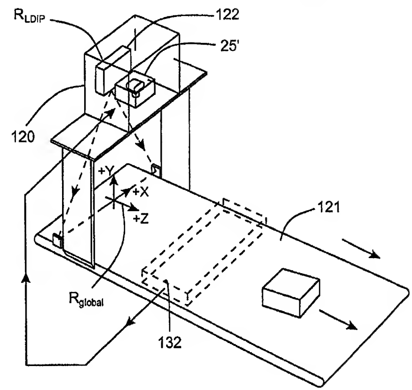


FIG. 9

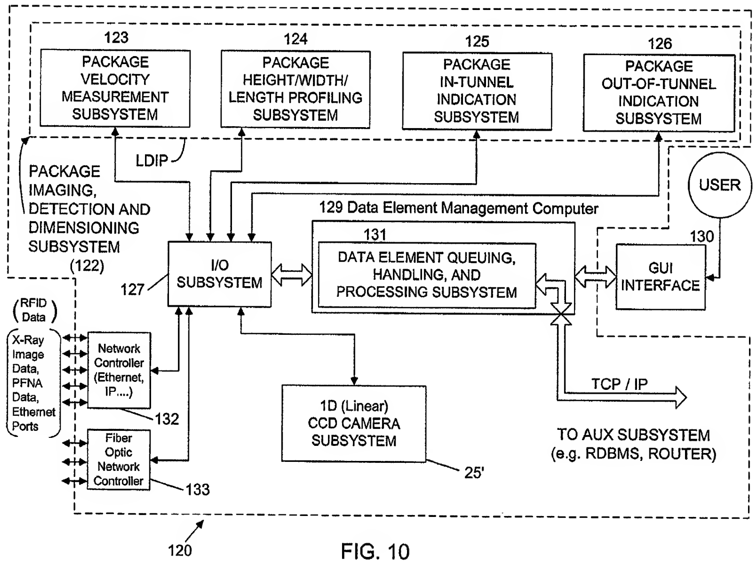

123
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
124
PACKAGE HEIGHT/WIDTH/ LENGTH PROFILING SUBSYSTEM
125
PACKAGE IN-TUNNEL INDICATION SUBSYSTEM
126
PACKAGE OUT-OF-TUNNEL INDICATION SUBSYSTEM
LDIP
PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM (122)
USER
129 Data Element Management Computer
131
DATA ELEMENT QUEUING, HANDLING, AND PROCESSING SUBSYSTEM
130
GUI INTERFACE
127
I/O SUBSYSTEM
(RFID Data)
(X-Ray Image Data, PFNA Data, Ethernet Ports)
Network Controller (Ethernet, IP....)
132
Fiber Optic Network Controller
133
1D (Linear) CCD CAMERA SUBSYSTEM
25'
TCP / IP
TO AUX SUBSYSTEM (e.g. RDBMS, ROUTER)
120

FIG. 10

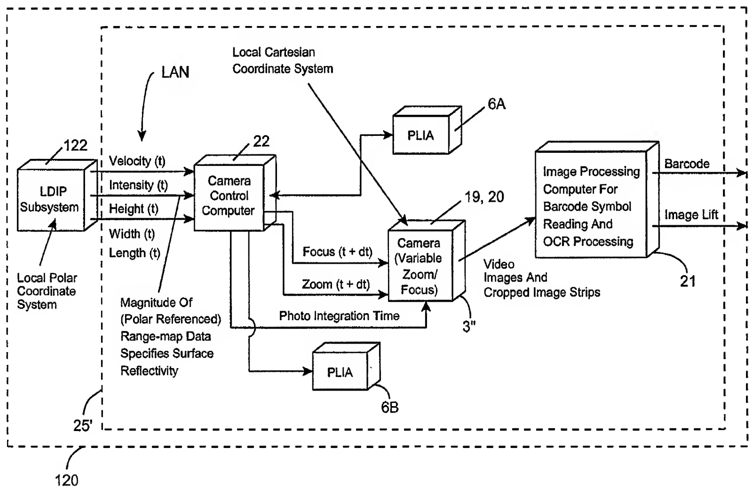

LAN
Local Cartesian
Coordinate System
6A
PLIA
122
22
LDIP
Subsystem
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
Camera
Control
Computer
19, 20
Image Processing
Computer For
Barcode Symbol
Reading And
OCR Processing
Barcode
Image Lift
Focus (t + dt)
Zoom (t + dt)
Camera
(Variable
Zoom/
Focus)
Video
Images And
Cropped Image Strips
21
Local Polar
Coordinate
System
Magnitude Of
(Polar Referenced)
Range-map Data
Specifies Surface
Reflectivity
Photo Integration Time
3"
PLIA
6B
25'
120

FIG. 11

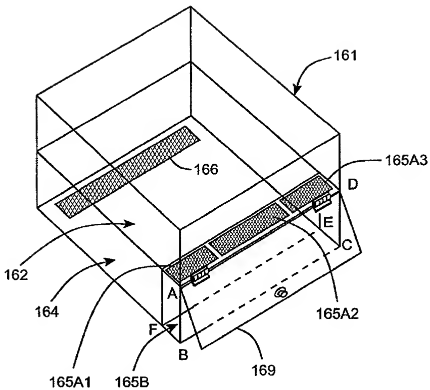


FIG. 12A

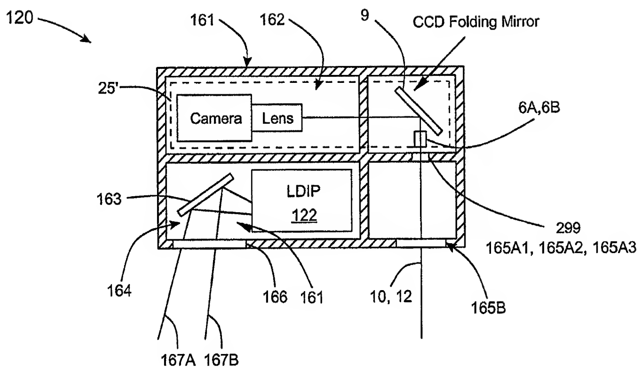
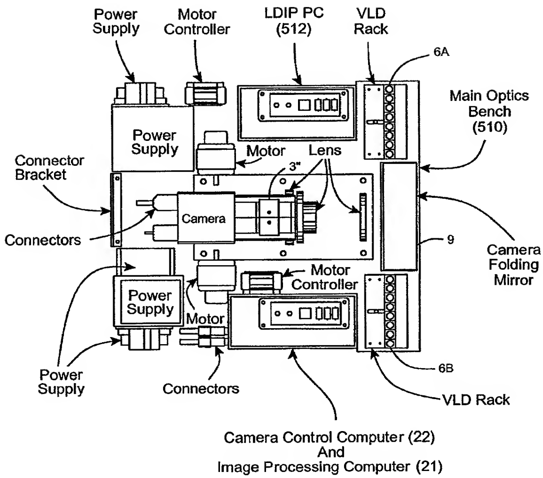

120
161
162
9
CCD Folding Mirror
25'
Camera
Lens
6A,6B
163
LDIP
122
299
165A1, 165A2, 165A3
164
166
161
10, 12
165B
167A
167B

FIG. 12B



Power Supply
Motor Controller
LDIP PC (512)
VLD Rack
6A
Main Optics Bench (510)
Power Supply
Connector Bracket
Motor
Lens
3"
Camera
Connectors
9
Camera Folding Mirror
Motor Controller
Power Supply
Motor
6B
Power Supply
Connectors
VLD Rack
Camera Control Computer (22) And Image Processing Computer (21)

FIG. 12C

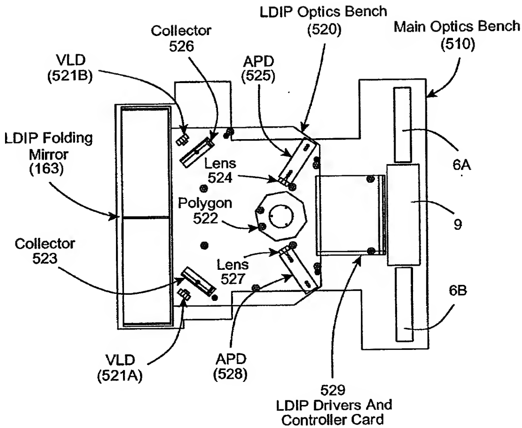
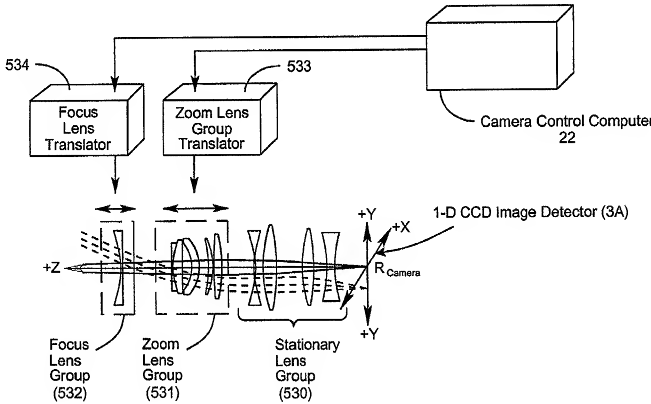

LDIP Optics Bench
(520)
Main Optics Bench
(510)
Collector
526
VLD
(521B)
APD
(525)
LDIP Folding
Mirror
(163)
Lens
524
Polygon
522
6A
9
Collector
523
Lens
527
6B
VLD
(521A)
APD
(528)
529
LDIP Drivers And
Controller Card

FIG. 12D



Main Optics Lens Groups

FIG. 12E

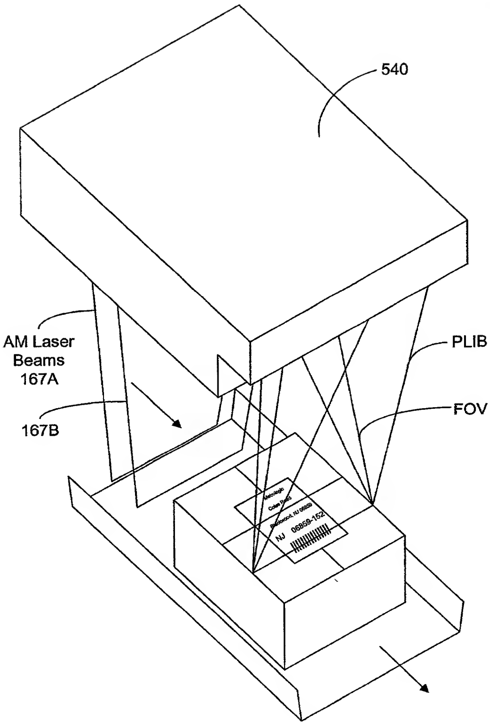


FIG. 13A

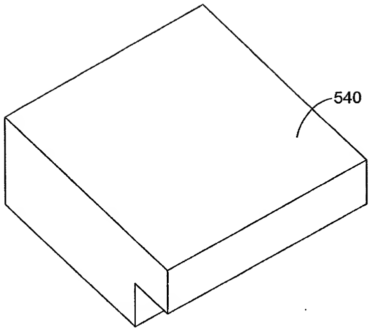


FIG. 13B

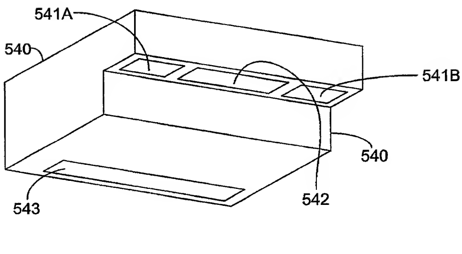


FIG. 13C

PLIIM-BASED PACKAGE IDENTIFICATION AND DIMENSIONING (PID) SYSTEM

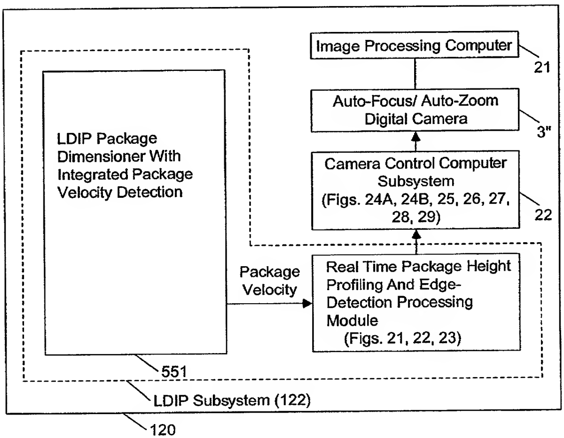


FIG. 14

LDIP REAL-TIME PACKAGE HEIGHT PROFILE AND EDGE DETECTION METHOD

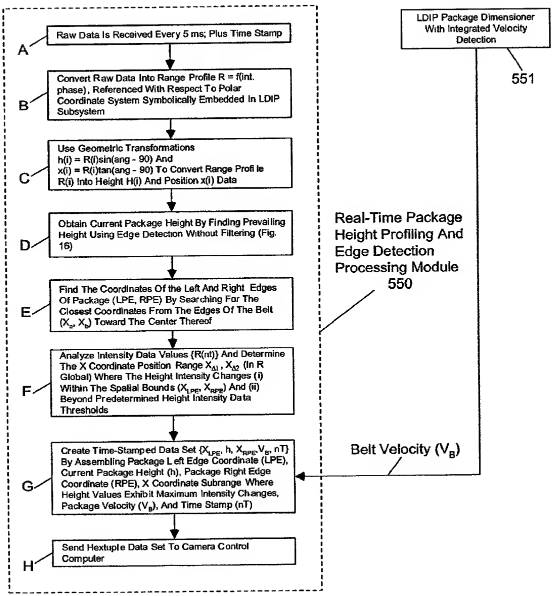
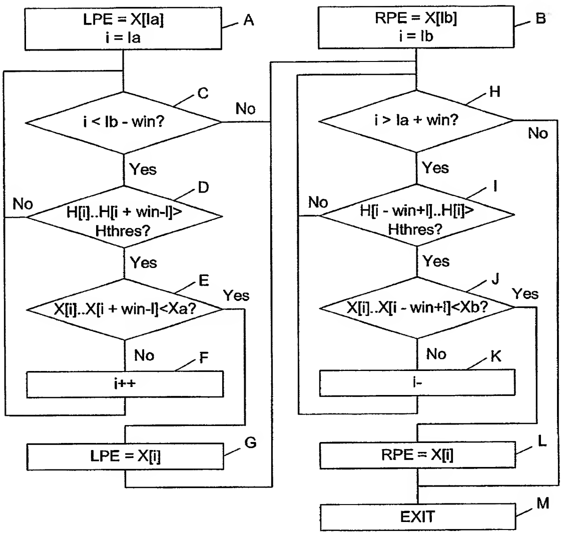


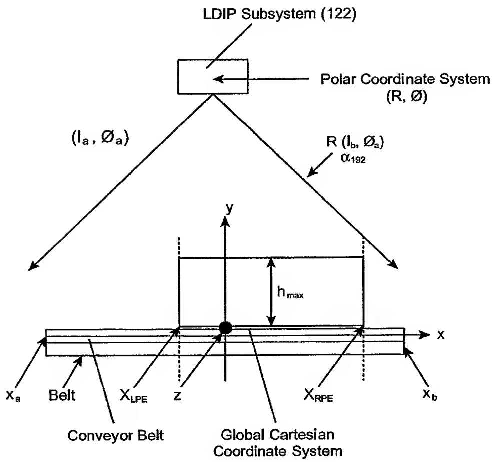
FIG. 15

LDIP REAL-TIME PACKAGE EDGE DETECTION



Xa = Location Of Belt Left Edge; Xb = Location Of Belt Right Edge
Ia = Belt Left Edge Pixel; Ib = Belt Right Edge Pixel
LPE = Left package Edge; RPE = Right Package Edge
H[] = Pixel Height Array; X[] = Pixel Location Array
win = Package detection Window

FIG. 16



LDIP Subsystem (122)
Polar Coordinate System
(R, Ø)
(la , Øa)
R (lb, Øa)
α192
y
hmax
x
xa
Belt
XLPE
z
XRPE
xb
Conveyor Belt
Global Cartesian
Coordinate System

FIG. 17

Information Measured At Scan Angles Before Coordinate Transformations

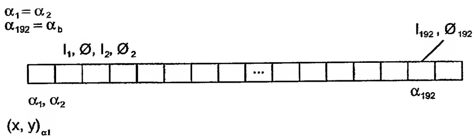


FIG. 17A

Range And Polar Angle Measures Taken At Scan Angle α Before Coordinate Transforms

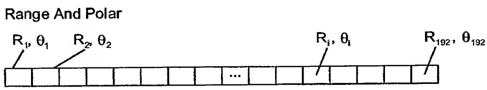


FIG. 17B

Measured Package Height And Position Values After Coordinate Transforms

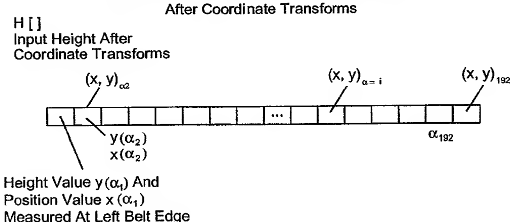


FIG. 17C

CAMERA CONTROL PROCESS CARRIED OUT WITHIN THE CAMERA CONTROL SUBSYSTEM OF EACH OBJECT IDENTIFICATION AND ATTRIBUTE ACQUISITION SYSTEM OF PRESENT INVENTION

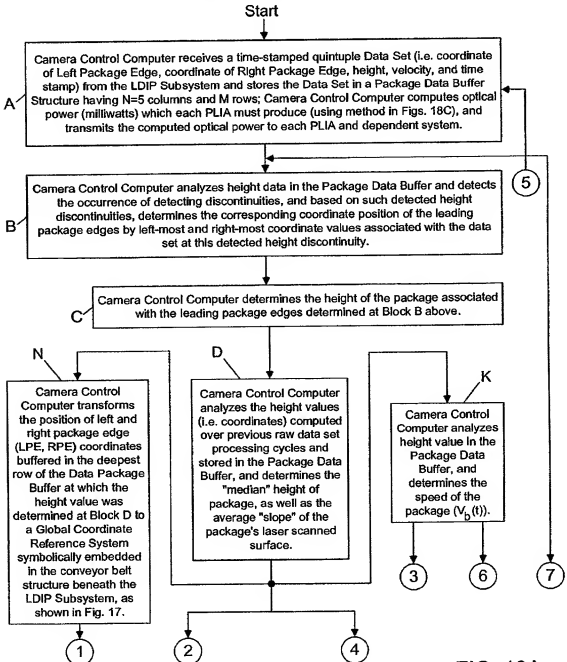
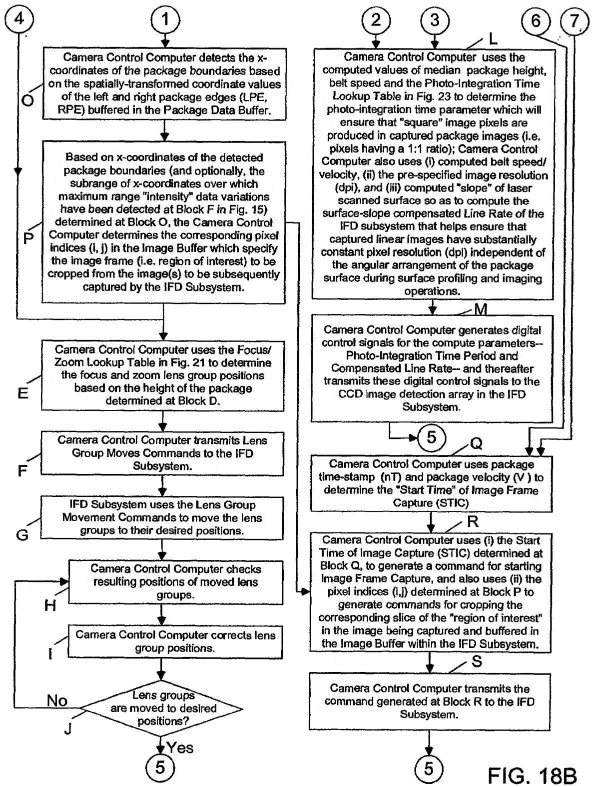


FIG. 18A



4
1
2
3
6
7
Camera Control Computer detects the x-coordinates of the package boundaries based on the spatially-transformed coordinate values of the left and right package edges (LPE, RPE) buffered in the Package Data Buffer.
O
Based on x-coordinates of the detected package boundaries (and optionally, the subrange of x-coordinates over which maximum range "intensity" data variations have been detected at Block F in Fig. 15) determined at Block O, the Camera Control Computer determines the corresponding pixel indices (i, j) in the Image Buffer which specify the image frame (i.e. region of interest) to be cropped from the image(s) to be subsequently captured by the IFD Subsystem.
P
Camera Control Computer uses the Focus/ Zoom Lookup Table in Fig. 21 to determine the focus and zoom lens group positions based on the height of the package determined at Block D.
E
Camera Control Computer transmits Lens Group Moves Commands to the IFD Subsystem.
F
IFD Subsystem uses the Lens Group Movement Commands to move the lens groups to their desired positions.
G
Camera Control Computer checks resulting positions of moved lens groups.
H
Camera Control Computer corrects lens group positions.
I
Lens groups are moved to desired positions?
No
J
Yes
5
L
Camera Control Computer uses the computed values of median package height, belt speed and the Photo-Integration Time Lookup Table in Fig. 23 to determine the photo-integration time parameter which will ensure that "square" image pixels are produced in captured package images (i.e. pixels having a 1:1 ratio); Camera Control Computer also uses (i) computed belt speed/ velocity, (ii) the pre-specified image resolution (dpi), and (iii) computed "slope" of laser scanned surface so as to compute the surface-slope compensated Line Rate of the IFD subsystem that helps ensure that captured linear images have substantially constant pixel resolution (dpi) independent of the angular arrangement of the package surface during surface profiling and imaging operations.
M
Camera Control Computer generates digital control signals for the compute parameters-- Photo-Integration Time Period and Compensated Line Rate-- and thereafter transmits these digital control signals to the CCD image detection array in the IFD Subsystem.
5
Q
Camera Control Computer uses package time-stamp (nT) and package velocity (V) to determine the "Start Time" of Image Frame Capture (STIC)
R
Camera Control Computer uses (i) the Start Time of Image Capture (STIC) determined at Block Q, to generate a command for starting Image Frame Capture, and also uses (ii) the pixel indices (i,j) determined at Block P to generate commands for cropping the corresponding slice of the "region of interest" in the image being captured and buffered in the Image Buffer within the IFD Subsystem.
S
Camera Control Computer transmits the command generated at Block R to the IFD Subsystem.
5

FIG. 18B

METHOD OF COMPUTING OPTICAL OUTPUT POWER FROM LASER DIODES IN A PLANAR LASER ILUMINATION ARRAY (PLIA) FOR CONTROLLING THE CONSTANT WHITE-LEVEL IN IMAGE PIXELS CAPTURED BY A PLIIM-BASED LINEAR IMAGER

A

Compute the Line Rate of a Linear Image Detection Array (dots/sec) based on computed Belt Velocity (inches/sec) and constant Image Resolution (dots/inch) desired, using equation:

Line Rate = (Belt Velocity) x (Image Resolution)

B

Compute the Photo-integration Time ΔT of the Linear Image Detection Array based on the computed Line Rate using the formula:

Photo-integration Time Period = 1/Line Rate

A

FIG. 18C1

A

Compute the Optical Power (milliwatts) of each PLIA based on the computed Photo-integration Time Period (ΔT) using the following formula:

$$\text{Optical Power of VLD (milliwatts)} = \frac{\text{constant}}{\text{Photo-integration Time Period } \Delta T}$$

FIG. 18C2

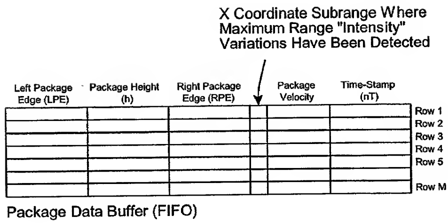

X Coordinate Subrange Where Maximum Range "Intensity" Variations Have Been Detected
Left Package Edge (LPE)
Package Height (h)
Right Package Edge (RPE)
Package Velocity
Time-Stamp (nT)
Row 1
Row 2
Row 3
Row 4
Row 5
Row M
Package Data Buffer (FIFO)

FIG. 19

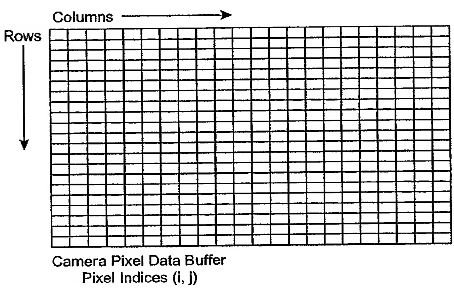

Columns
Rows
Camera Pixel Data Buffer
Pixel Indices (i, j)

FIG. 20

Zoom And Focus Lens Group Position
Look-Up Table

Distance From Camera H (mm)	Zoom Group Distance (mm) Y (Zoom)	Focus Group Distance (mm) Y (Focus)
1000	21.57489228	2.47E-05
1100	19.38089696	10.99009783
1200	17.10673434	20.65783177
1300	14.77137314	29.10917002
1400	12.39153565	36.47312595
1500	9.979114358	42.87845436
1600	7.540639114	48.44003358
1700	5.078794775	53.25495831
1800	2.595989366	57.40834303
1900	0.099972739	60.98883615
(Use Interpolation Techniques For Working Distances Between Listed Points In Table)		

FIG. 21

* Note: The focal distance and zoom (eff. focal length) of camera lens are coupled (inter-dependant) in this commercial embodiment.

Camera Has A Fixed Aperture F56

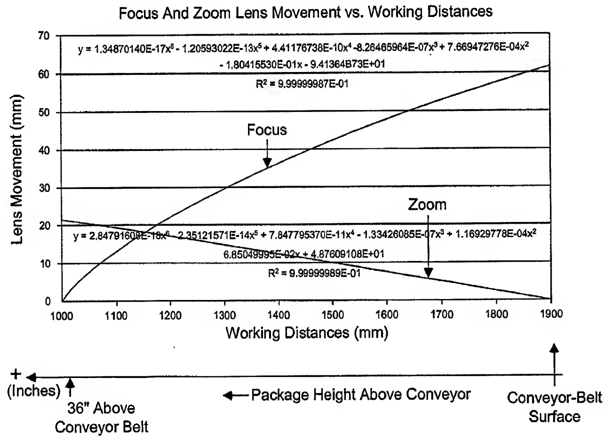


FIG. 22

Photo-Integration Time Look-Up Table

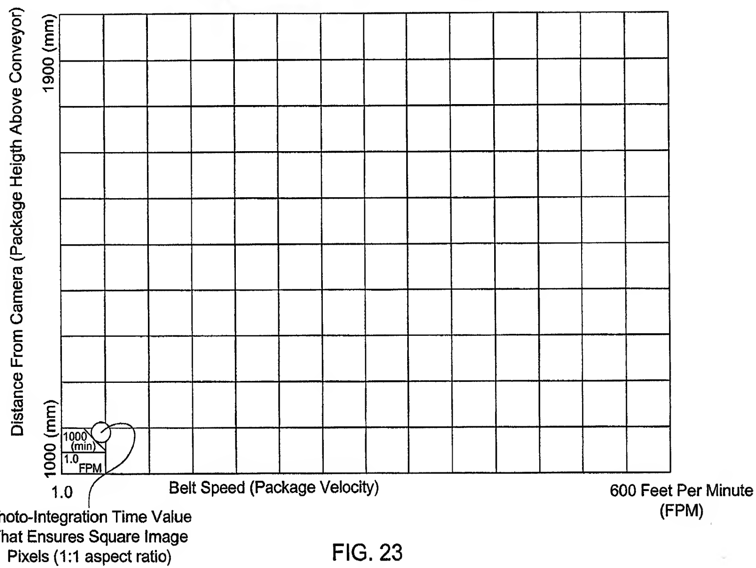


FIG. 23

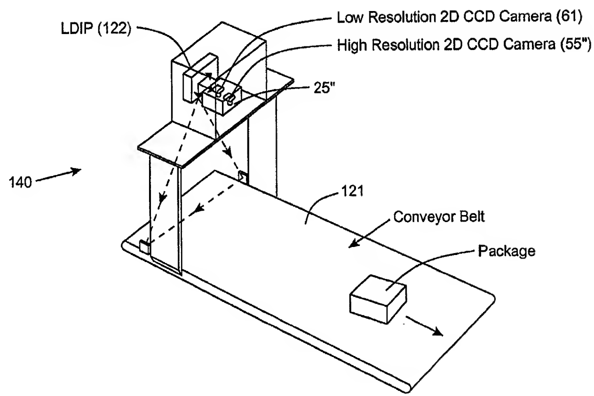

LDIP (122)
Low Resolution 2D CCD Camera (61)
High Resolution 2D CCD Camera (55")
25"
140
121
Conveyor Belt
Package

FIG. 24

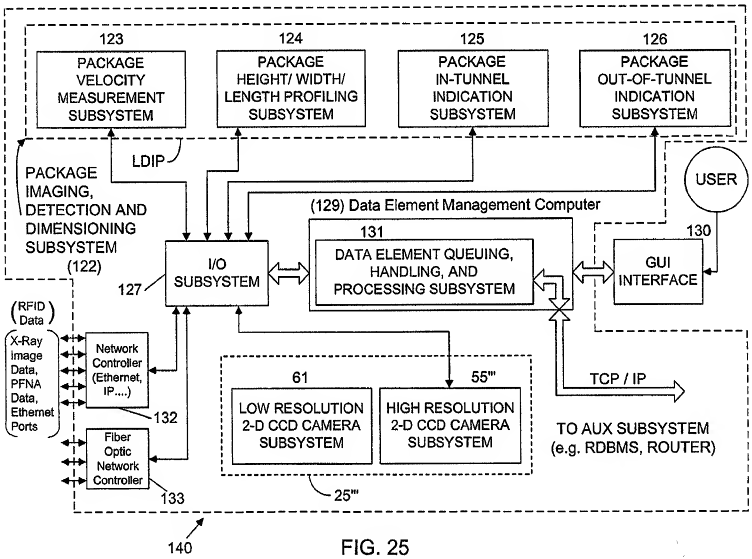

123
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
124
PACKAGE HEIGHT/ WIDTH/ LENGTH PROFILING SUBSYSTEM
125
PACKAGE IN-TUNNEL INDICATION SUBSYSTEM
126
PACKAGE OUT-OF-TUNNEL INDICATION SUBSYSTEM
LDIP
PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM (122)
USER
(129) Data Element Management Computer
127
I/O SUBSYSTEM
131
DATA ELEMENT QUEUING, HANDLING, AND PROCESSING SUBSYSTEM
130
GUI INTERFACE
(RFID Data)
X-Ray Image Data, PFNA Data, Ethernet Ports
Network Controller (Ethernet, IP....)
132
Fiber Optic Network Controller
133
61
LOW RESOLUTION 2-D CCD CAMERA SUBSYSTEM
55'''
HIGH RESOLUTION 2-D CCD CAMERA SUBSYSTEM
25'''
TCP / IP
TO AUX SUBSYSTEM (e.g. RDBMS, ROUTER)
140

FIG. 25

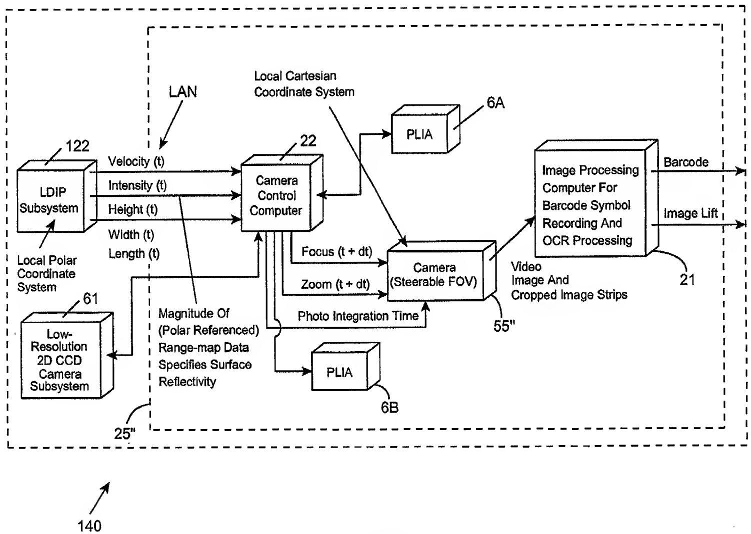

LAN
Local Cartesian
Coordinate System
6A
PLIA
122
22
LDIP
Subsystem
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
Camera
Control
Computer
Image Processing
Computer For
Barcode Symbol
Recording And
OCR Processing
Barcode
Image Lift
Local Polar
Coordinate
System
Focus (t + dt)
Zoom (t + dt)
Camera
(Steerable FOV)
Video
Image And
Cropped Image Strips
21
61
Low-
Resolution
2D CCD
Camera
Subsystem
Magnitude Of
(Polar Referenced)
Range-map Data
Specifies Surface
Reflectivity
Photo Integration Time
55"
PLIA
6B
25"
140

FIG. 26

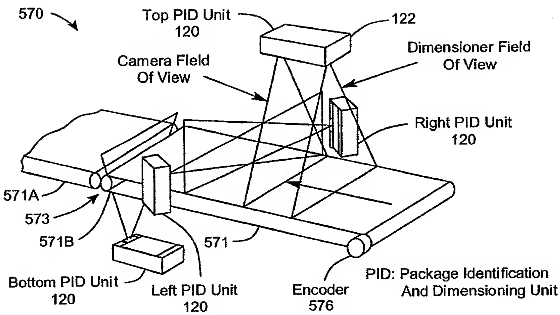

570
Top PID Unit
120
122
Dimensioner Field
Of View
Camera Field
Of View
Right PID Unit
120
571A
573
571B
571
Bottom PID Unit
120
Left PID Unit
120
Encoder
576
PID: Package Identification
And Dimensioning Unit

FIG. 27

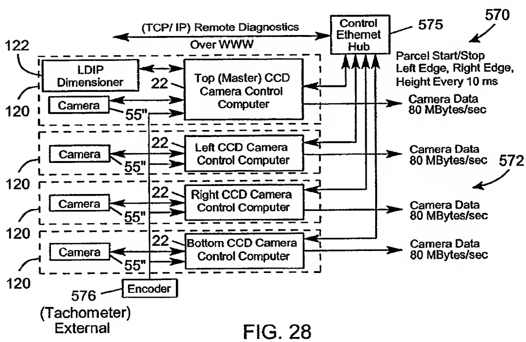

(TCP/ IP) Remote Diagnostics
Over WWW
Control
Ethernet
Hub
575
570
122
LDIP
Dimensioner
22
Top (Master) CCD
Camera Control
Computer
Parcel Start/Stop
Left Edge, Right Edge,
Height Every 10 ms
120
Camera
55"
Camera Data
80 MBytes/sec
Camera
22
Left CCD Camera
Control Computer
55"
Camera Data
80 MBytes/sec
572
120
Camera
22
Right CCD Camera
Control Computer
55"
Camera Data
80 MBytes/sec
120
Camera
22
Bottom CCD Camera
Control Computer
55"
Camera Data
80 MBytes/sec
120
576
Encoder
(Tachometer)
External

FIG. 28

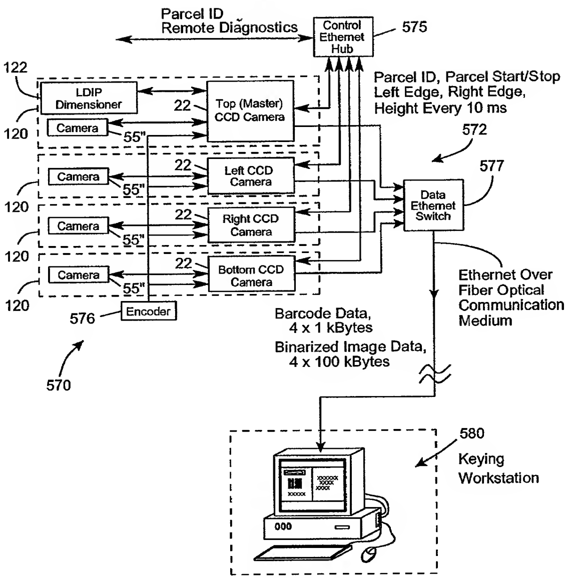
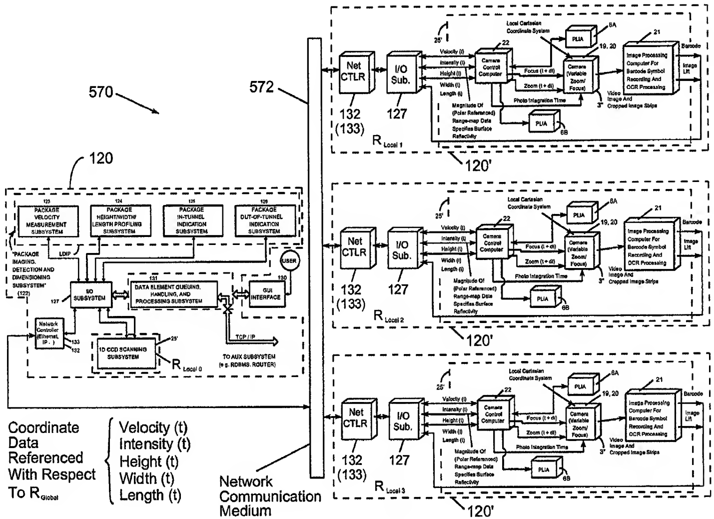

Parcel ID
Remote Diagnostics
Control Ethernet Hub
575
122
LDIP Dimensioner
Top (Master) CCD Camera
22
Camera
55"
120
Parcel ID, Parcel Start/Stop
Left Edge, Right Edge,
Height Every 10 ms
572
577
Left CCD Camera
Right CCD Camera
Bottom CCD Camera
Data Ethernet Switch
Ethernet Over
Fiber Optical
Communication
Medium
Encoder
576
Barcode Data,
4 x 1 kBytes
Binarized Image Data,
4 x 100 kBytes
570
580
Keying
Workstation

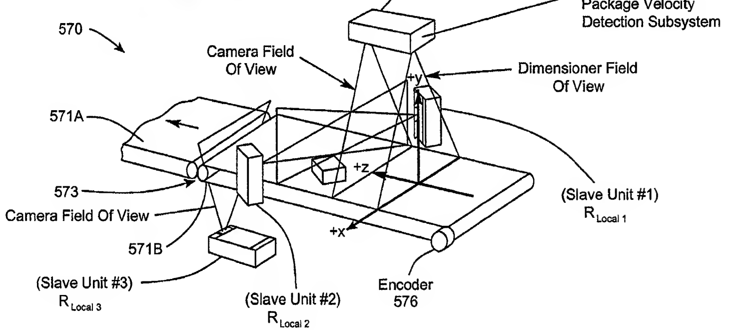
FIG. 29



570
572
120
123 PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
124 PACKAGE HEIGHT/WIDTH/ LENGTH PROFILING SUBSYSTEM
125 PACKAGE IN-TUNNEL INDICATION SUBSYSTEM
126 PACKAGE OUT-OF-TUNNEL INDICATION SUBSYSTEM
"PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM" (122)
LDIP
127 I/O SUBSYSTEM
131 DATA ELEMENT QUEUING, HANDLING, AND PROCESSING SUBSYSTEM
130 GUI INTERFACE
USER
Network Controller (Ethernet, IP...)
133
132
1D CCD SCANNING SUBSYSTEM
25'
$R_{Local\ 0}$
TCP / IP
TO AUX SUBSYSTEM (e.g. RDBMS, ROUTER)
Coordinate Data Referenced With Respect To R_{Global}
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
Network Communication Medium
Net CTLR
I/O Sub.
132 (133)
127
$R_{Local\ 1}$
$R_{Local\ 2}$
$R_{Local\ 3}$
120'
25'
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
22
Camera Control Computer
Local Cartesian Coordinate System
PLIA
6A
6B
19, 20
Camera (Variable Zoom/ Focus)
Focus (t + dt)
Zoom (t + dt)
Photo Integration Time
Magnitude Of (Polar Referenced) Range-map Data Specifies Surface Reflectivity
3"
Video Image And Cropped Image Strips
21
Image Processing Computer For Barcode Symbol Recording And OCR Processing
Barcode
Image Lift

FIG. 30

CCD Camera-Based Tunnel System Employing Package Coordinate Data Driven Method Of Automatic Camera Zoom And Focus Control



$$\text{Package Coordinate Data}\,\|_{R_{Global}} \xrightarrow{HG} \text{Package Coordinate Data}\,\|\;R_{Local\,I}$$

FIG. 31

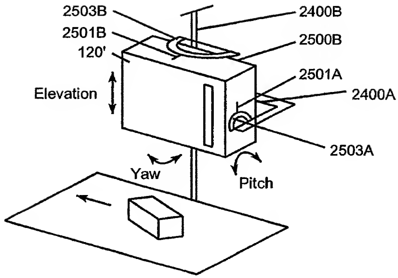


FIG. 31A

A — For each package transported through tunnel system, the master unit (with package dimensioning subsystem and velocity detection subsystem) generates package height, width, length and velocity data $(H, W, L, V)_G$, referenced with respect to global coordinate reference system R_{global}, and transmits such package dimension data to each slave unit downstream, using the systems data communications network.

↓

B — Each slave unit receives the transmitted package height, width and length data $\{H, W, L, V\}_G$ and converts this coordinate information into the slave unit's local coordinate reference system $R_{Local\,I}$, $\{H, W, L, V\}_l$

↓

C — The camera control computer in each slave unit uses the converted package height, width, length data $\{H, W, L\}_i$ and package velocity data to generate camera control signals for driving the camera subsystem in the slave unit to zoom and focus in on the transported package as it moves by the slave unit, while ensuring that captured images having substantially constant O.P.I. Resolution and 1:1 aspect ratio.

↓

A

FIG. 32A

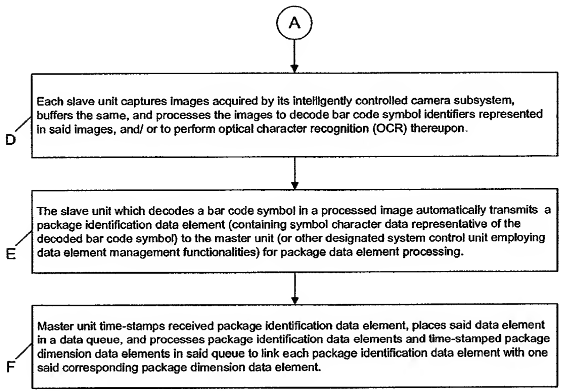

A
D
Each slave unit captures images acquired by its intelligently controlled camera subsystem, buffers the same, and processes the images to decode bar code symbol identifiers represented in said images, and/ or to perform optical character recognition (OCR) thereupon.
E
The slave unit which decodes a bar code symbol in a processed image automatically transmits a package identification data element (containing symbol character data representative of the decoded bar code symbol) to the master unit (or other designated system control unit employing data element management functionalities) for package data element processing.
F
Master unit time-stamps received package identification data element, places said data element in a data queue, and processes package identification data elements and time-stamped package dimension data elements in said queue to link each package identification data element with one said corresponding package dimension data element.

FIG. 32B

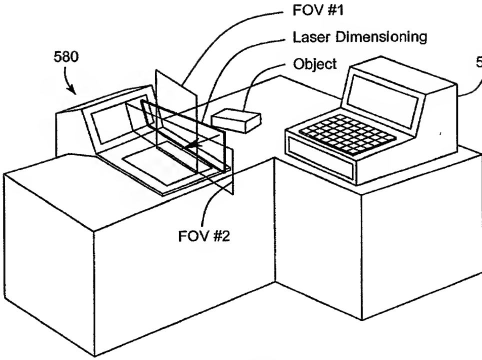


FIG. 33A

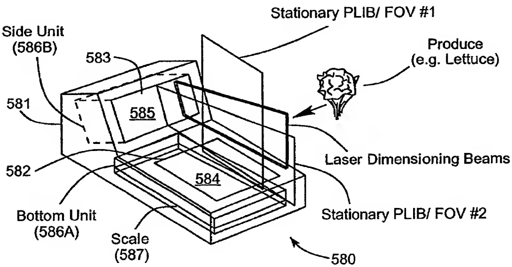
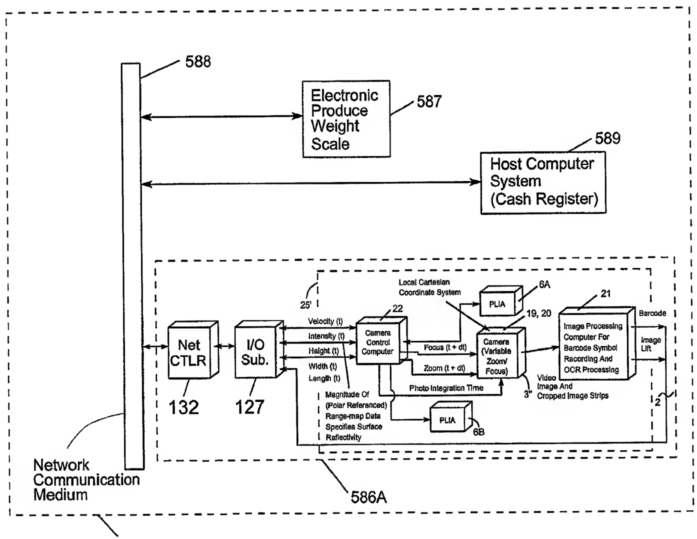


FIG. 33B



588
Electronic Produce Weight Scale
587
589
Host Computer System (Cash Register)
Net CTLR
132
I/O Sub.
127
25'
Local Cartesian Coordinate System
6A
PLIA
22
Camera Control Computer
19, 20
Camera (Variable Zoom/ Focus)
21
Image Processing Computer For Barcode Symbol Recording And OCR Processing
Barcode
Image Lift
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
Focus (t + dt)
Zoom (t + dt)
Photo Integration Time
Magnitude Of (Polar Referenced) Range-map Data Specifies Surface Reflectivity
PLIA
6B
3"
Video Image And Cropped Image Strips
2
Network Communication Medium
586A
580

FIG. 33C1

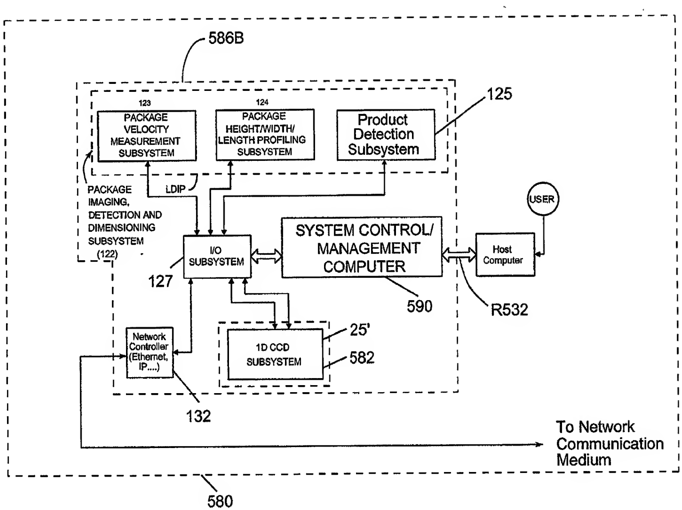

586B
123
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
124
PACKAGE HEIGHT/WIDTH/ LENGTH PROFILING SUBSYSTEM
Product Detection Subsystem
125
LDIP
PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM (122)
USER
I/O SUBSYSTEM
SYSTEM CONTROL/ MANAGEMENT COMPUTER
Host Computer
127
590
R532
Network Controller (Ethernet, IP....)
1D CCD SUBSYSTEM
25'
582
132
To Network Communication Medium
580

FIG. 33C2

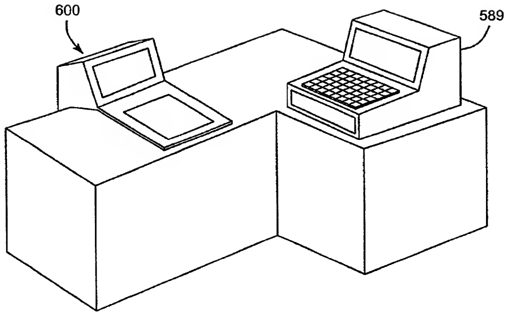


FIG. 34A

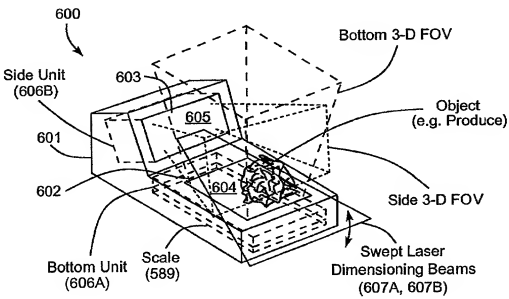


FIG. 34B

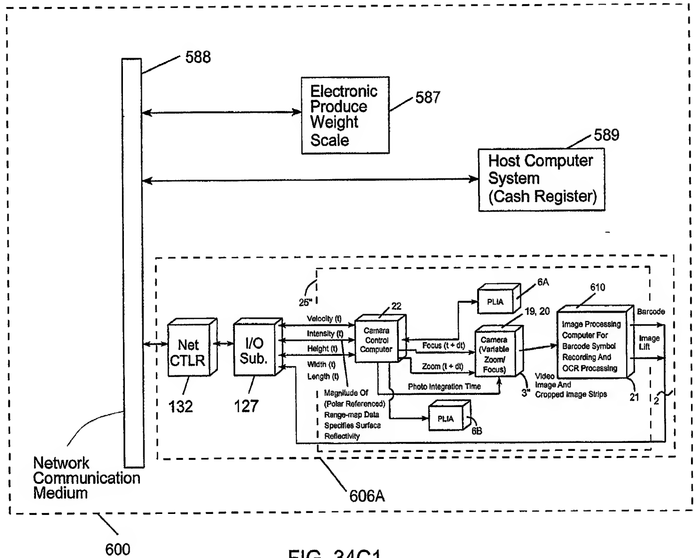

588
Electronic Produce Weight Scale
587
589
Host Computer System (Cash Register)
Net CTLR
132
I/O Sub.
127
Velocity (t)
Intensity (t)
Height (t)
Width (t)
Length (t)
Magnitude Of (Polar Referenced) Range-map Data Specifies Surface Reflectivity
25"
22
Camera Control Computer
Focus (t + dt)
Zoom (t + dt)
Photo Integration Time
PLIA
6A
PLIA
6B
19, 20
Camera (Variable Zoom/ Focus)
3"
Video Image And Cropped Image Strips
610
Image Processing Computer For Barcode Symbol Recording And OCR Processing
21
Barcode
Image Lift
2
Network Communication Medium
606A
600

FIG. 34C1

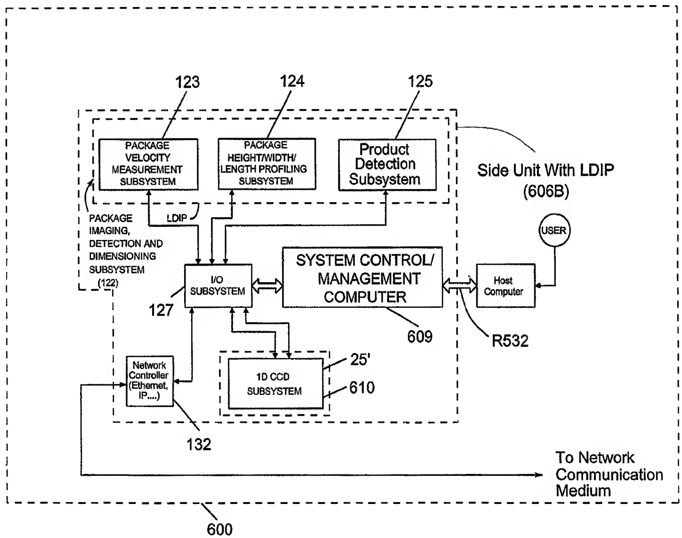

123
124
125
PACKAGE VELOCITY MEASUREMENT SUBSYSTEM
PACKAGE HEIGHT/WIDTH/ LENGTH PROFILING SUBSYSTEM
Product Detection Subsystem
Side Unit With LDIP (606B)
LDIP
PACKAGE IMAGING, DETECTION AND DIMENSIONING SUBSYSTEM (122)
USER
I/O SUBSYSTEM
SYSTEM CONTROL/ MANAGEMENT COMPUTER
Host Computer
127
609
R532
Network Controller (Ethernet, IP....)
1D CCD SUBSYSTEM
25'
610
132
To Network Communication Medium
600

FIG. 34C2

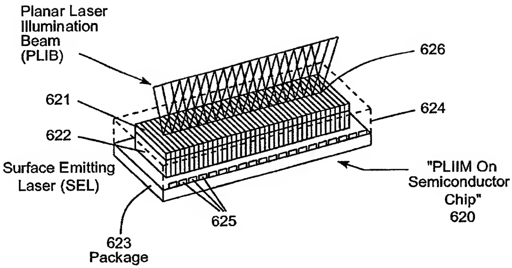


FIG. 35A

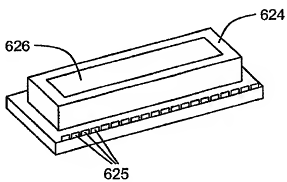


FIG. 35B

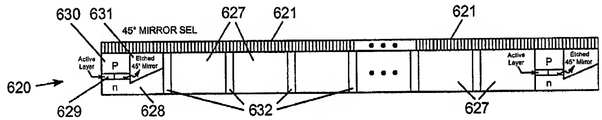


FIG. 36A

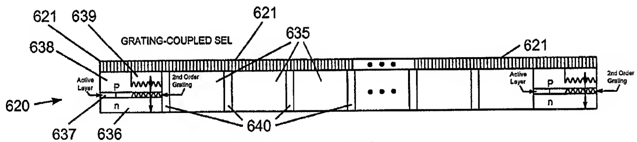


FIG. 36B

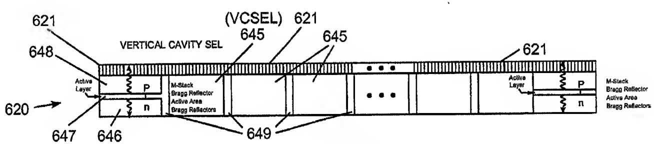
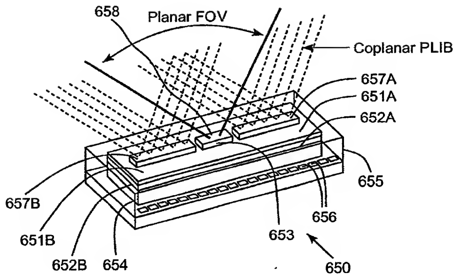


FIG. 36C



658
Planar FOV
Coplanar PLIB
657A
651A
652A
655
656
653
650
657B
651B
652B
654

FIG. 37

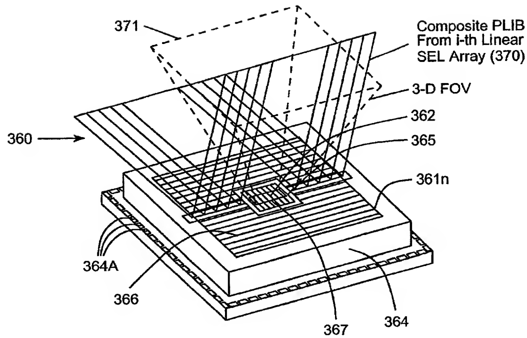


FIG. 38A

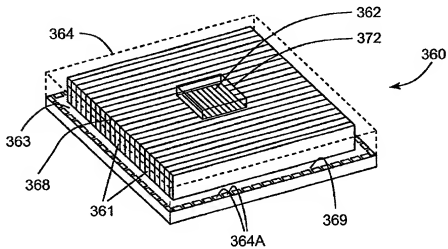


FIG. 38B

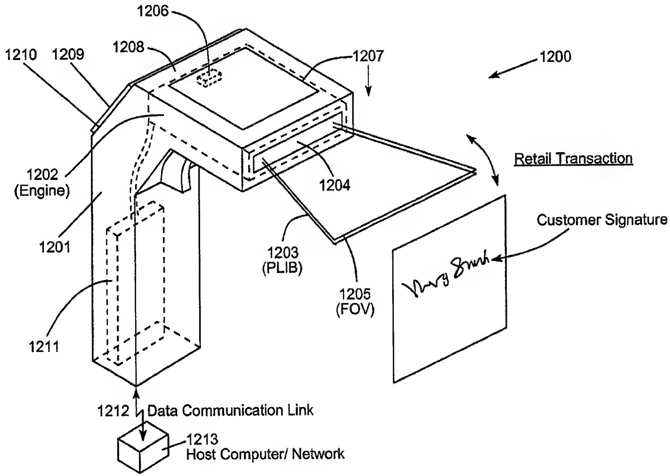

1200
1206
1208
1210
1209
1207
1202
(Engine)
1201
1211
1204
1203
(PLIB)
1205
(FOV)
Retail Transaction
Customer Signature
1212
Data Communication Link
1213
Host Computer/ Network

FIG. 39A

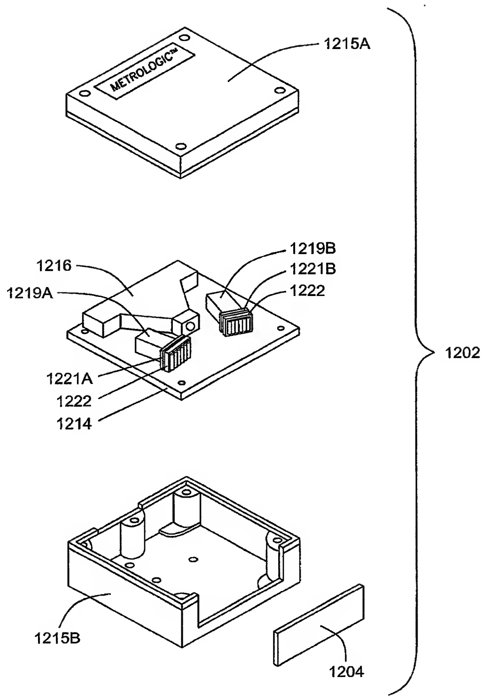

1215A
METROLOGIC™
1219B
1216
1221B
1219A
1222
1202
1221A
1222
1214
1215B
1204

FIG. 39B

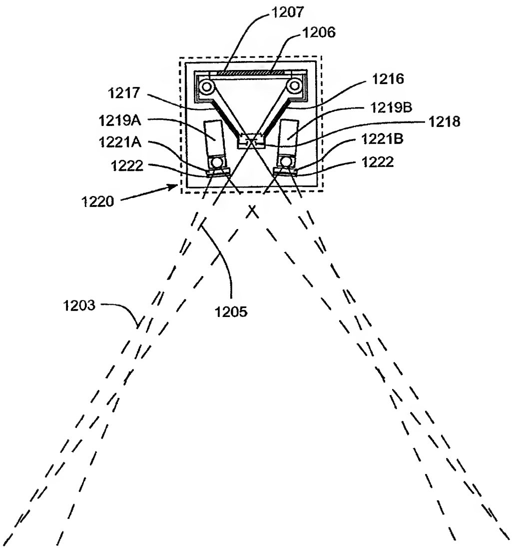

1207
1206
1216
1217
1219B
1219A
1218
1221A
1221B
1222
1222
1220
1203
1205

FIG. 39C

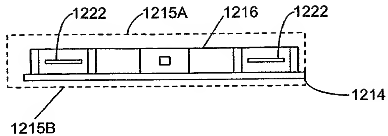


FIG. 39D

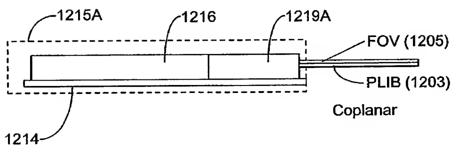


FIG. 39E

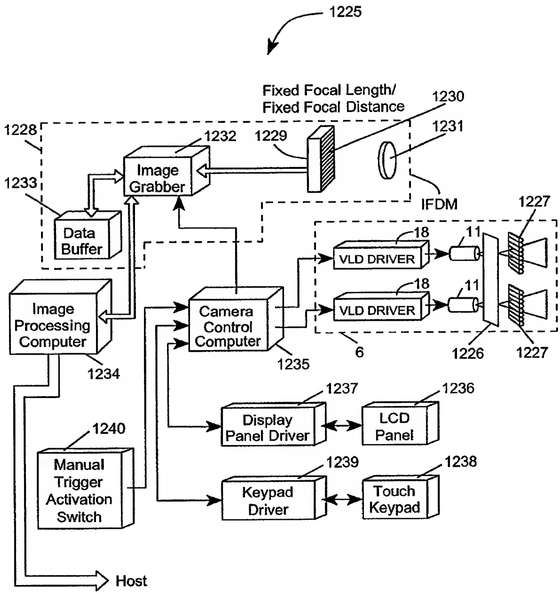
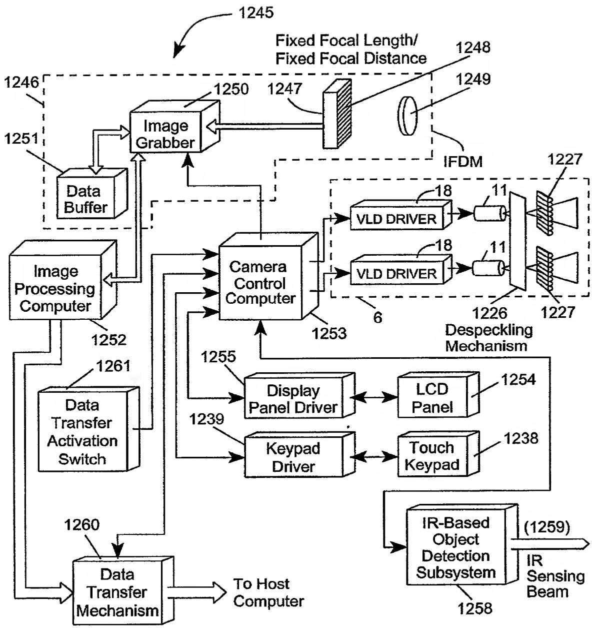
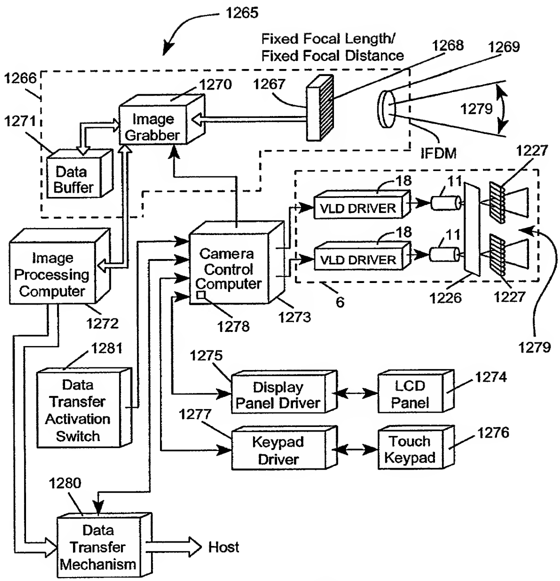

1225
Fixed Focal Length/
Fixed Focal Distance
1230
1231
1228
1232
1229
Image
Grabber
1233
IFDM
1227
Data
Buffer
18
11
VLD DRIVER
18
11
VLD DRIVER
Image
Processing
Computer
Camera
Control
Computer
6
1226
1227
1234
1235
1237
1236
Display
Panel Driver
LCD
Panel
1240
Manual
Trigger
Activation
Switch
1239
1238
Keypad
Driver
Touch
Keypad
Host

FIG. 40A1



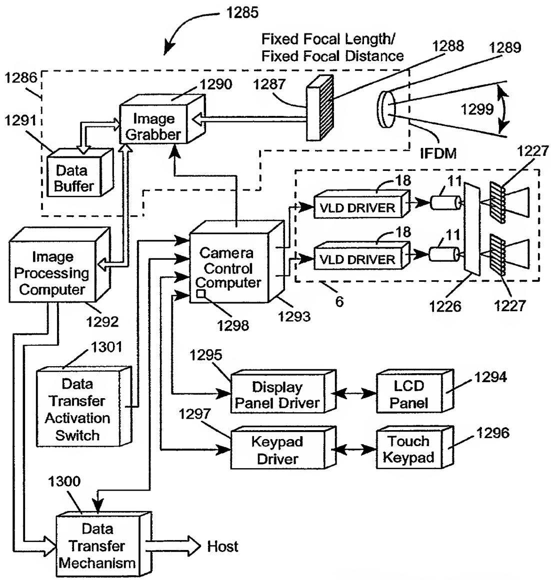
Automatic with IR Object Detection

FIG. 40A2



Automatic with Laser Based Object Detection

FIG. 40A3



<u>Automatic with Passive CCD Based Object Detection</u>

FIG. 40A4

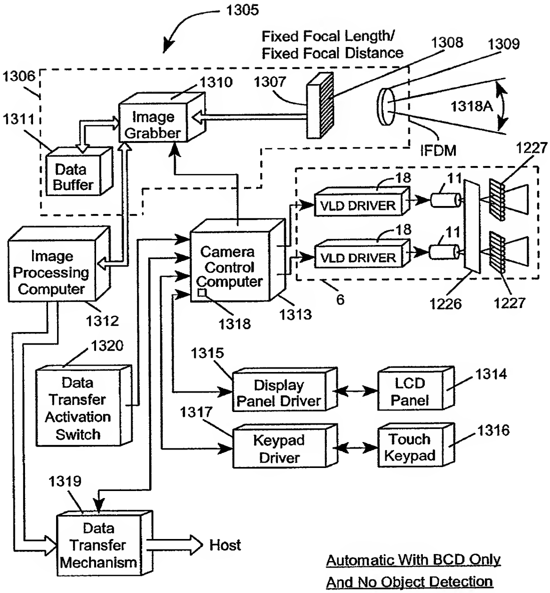
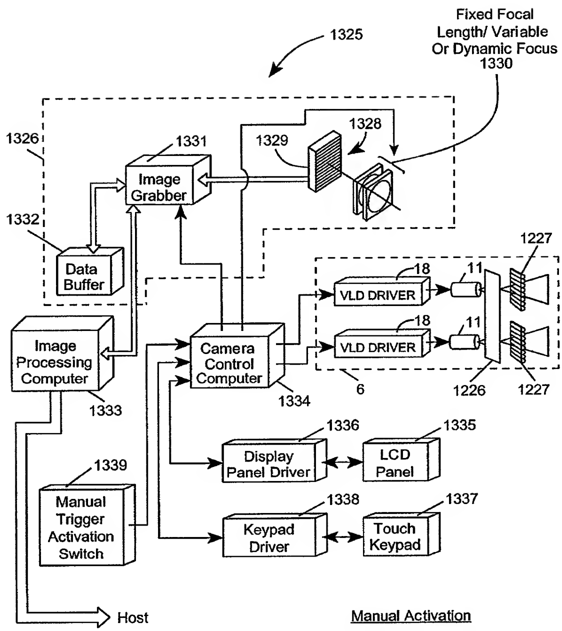
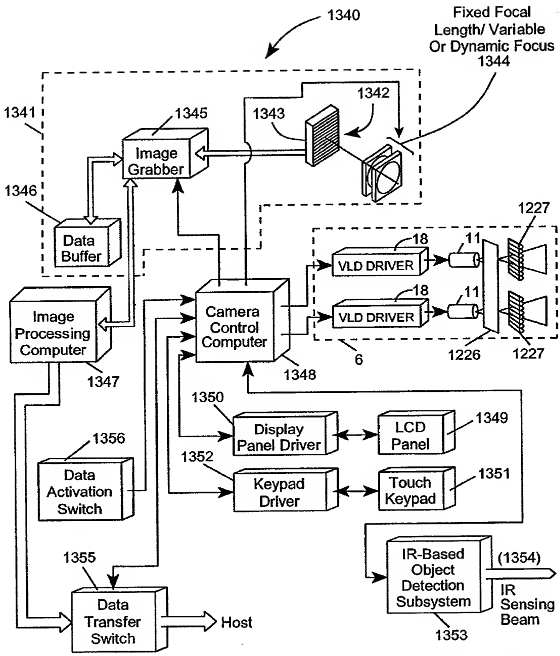

1305
Fixed Focal Length/
Fixed Focal Distance
1308
1309
1306
1310
1307
1318A
1311
Image
Grabber
Data
Buffer
IFDM
1227
18
11
VLD DRIVER
18
11
VLD DRIVER
Image
Processing
Computer
Camera
Control
Computer
6
1226
1227
1312
1318
1313
1320
1315
Data
Transfer
Activation
Switch
Display
Panel Driver
LCD
Panel
1314
1317
Keypad
Driver
Touch
Keypad
1316
1319
Data
Transfer
Mechanism
Host
Automatic With BCD Only
And No Object Detection

FIG. 40A5



1325
Fixed Focal Length/ Variable Or Dynamic Focus 1330
1326
1331
1329
1328
Image Grabber
1332
Data Buffer
1227
18
11
VLD DRIVER
18
11
VLD DRIVER
Image Processing Computer
Camera Control Computer
1333
1334
6
1226
1227
1336
1335
Display Panel Driver
LCD Panel
1339
1338
1337
Manual Trigger Activation Switch
Keypad Driver
Touch Keypad
Host
Manual Activation

FIG. 40B1



Automatic With IR-Based Object Detection

FIG. 40B2

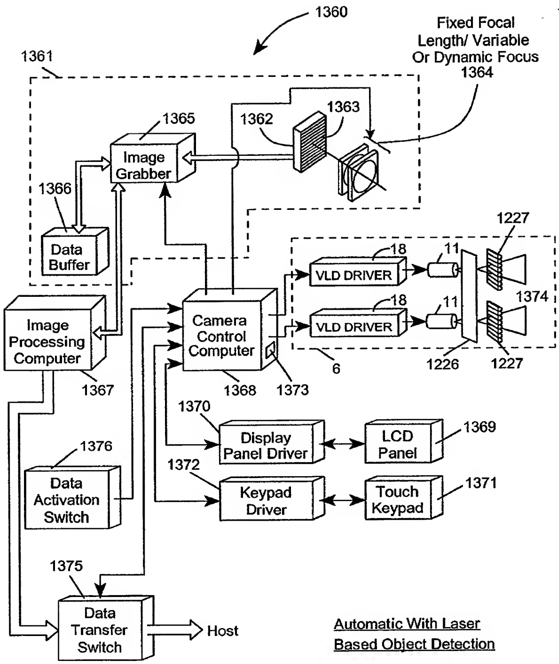
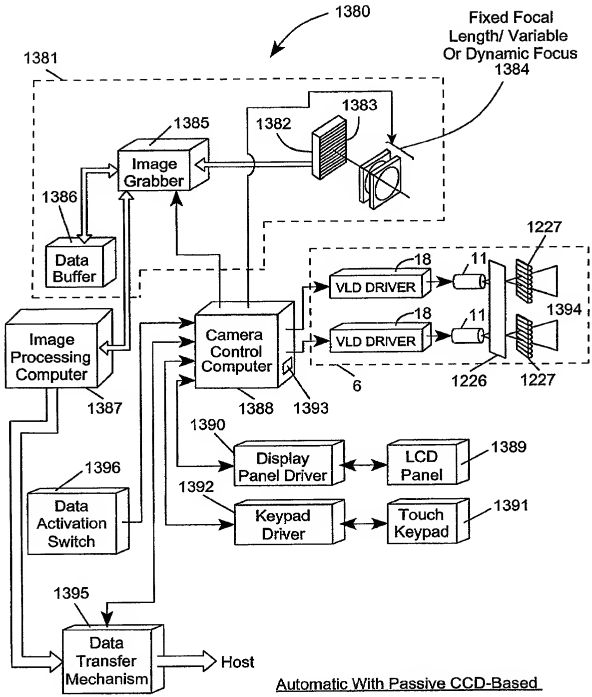

1360
1361
Fixed Focal Length/ Variable Or Dynamic Focus
1364
1363
1362
1365
Image Grabber
1366
Data Buffer
1227
18
11
VLD DRIVER
18
11
VLD DRIVER
1374
Image Processing Computer
Camera Control Computer
6
1226
1227
1367
1368
1373
1370
Display Panel Driver
LCD Panel
1369
1376
1372
Keypad Driver
Touch Keypad
1371
Data Activation Switch
1375
Data Transfer Switch
Host
Automatic With Laser Based Object Detection

FIG. 40B3



Automatic With Passive CCD-Based Object Detection

FIG. 40B4

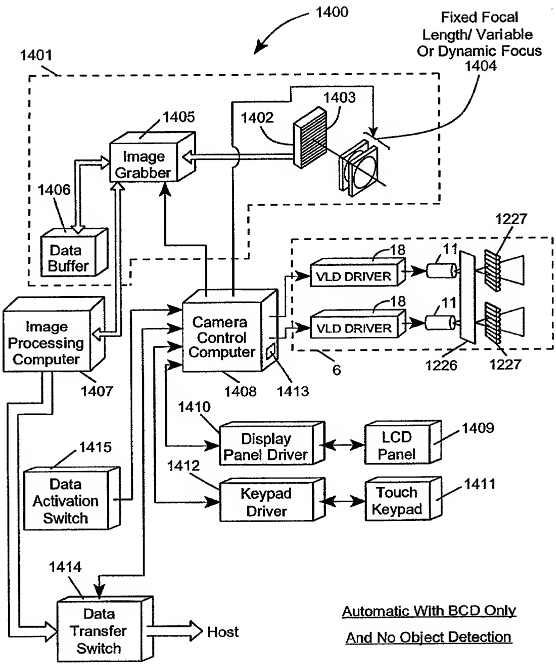
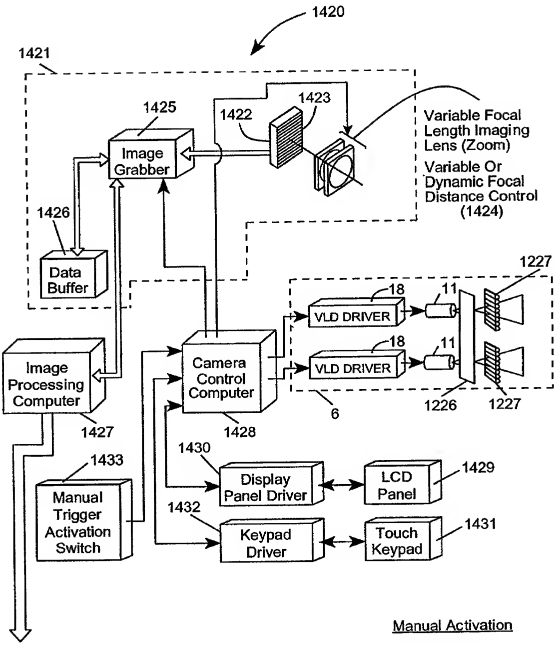

1400
1401
Fixed Focal
Length/ Variable
Or Dynamic Focus
1404
1403
1405
1402
Image
Grabber
1406
Data
Buffer
1227
18
11
VLD DRIVER
18
11
VLD DRIVER
Image
Processing
Computer
Camera
Control
Computer
1407
1408
1413
6
1226
1227
1410
Display
Panel Driver
LCD
Panel
1409
1415
1412
Keypad
Driver
Touch
Keypad
1411
Data
Activation
Switch
1414
Data
Transfer
Switch
Host
Automatic With BCD Only
And No Object Detection

FIG. 40B5



1420
1421
1425
1422
1423
Image Grabber
Variable Focal Length Imaging Lens (Zoom)
Variable Or Dynamic Focal Distance Control (1424)
1426
Data Buffer
1227
18
11
VLD DRIVER
18
11
VLD DRIVER
Image Processing Computer
Camera Control Computer
1226
1227
6
1427
1428
1430
1433
Display Panel Driver
LCD Panel
1429
Manual Trigger Activation Switch
1432
Keypad Driver
Touch Keypad
1431
Manual Activation

FIG. 40C1

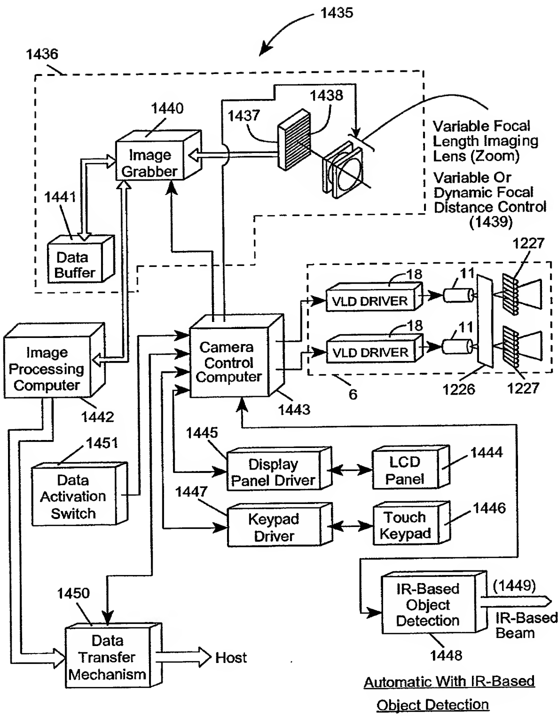

1435
1436
1440
1437
1438
Image Grabber
Variable Focal Length Imaging Lens (Zoom)
Variable Or Dynamic Focal Distance Control (1439)
1441
Data Buffer
1227
18
11
VLD DRIVER
18
11
VLD DRIVER
Image Processing Computer
Camera Control Computer
6
1226
1227
1442
1443
1445
1451
Data Activation Switch
Display Panel Driver
LCD Panel
1444
1447
Keypad Driver
Touch Keypad
1446
1450
IR-Based Object Detection
(1449)
IR-Based Beam
Data Transfer Mechanism
Host
1448
Automatic With IR-Based Object Detection

FIG. 40C2

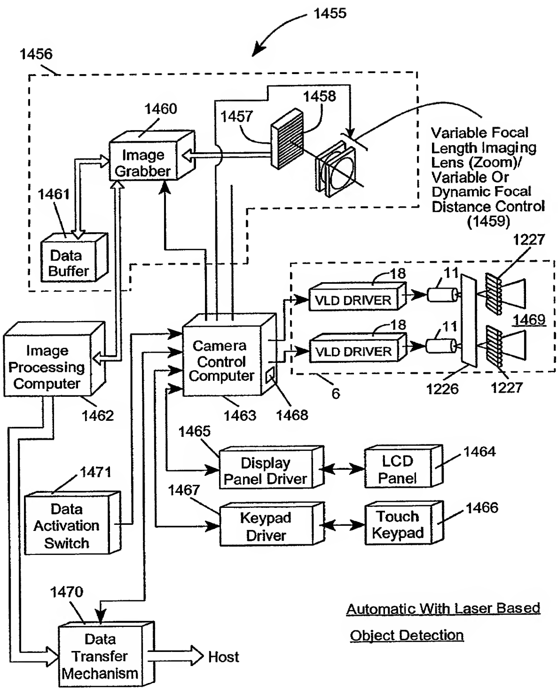
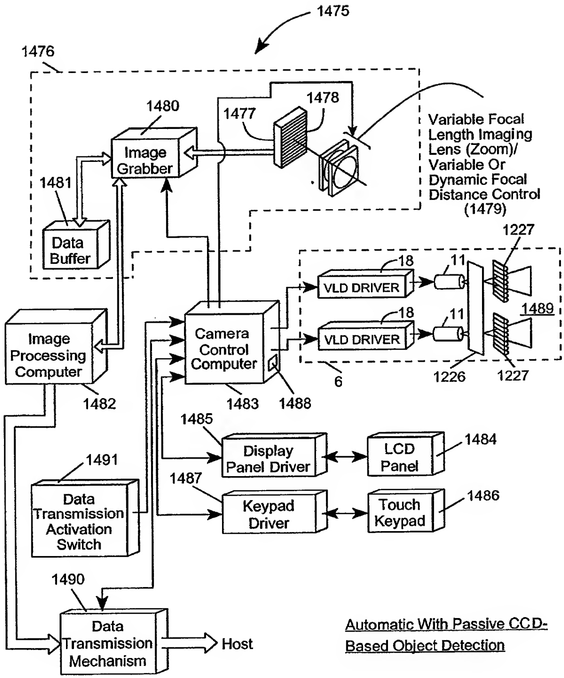

1455
1456
1460
1458
1457
Image Grabber
Variable Focal Length Imaging Lens (Zoom)/ Variable Or Dynamic Focal Distance Control (1459)
1461
Data Buffer
1227
18
11
VLD DRIVER
1469
18
11
VLD DRIVER
Image Processing Computer
Camera Control Computer
6
1226
1227
1462
1463
1468
1465
Display Panel Driver
LCD Panel
1464
1471
1467
Keypad Driver
Touch Keypad
1466
Data Activation Switch
1470
Automatic With Laser Based Object Detection
Data Transfer Mechanism
Host

FIG. 40C3



<u>Automatic With Passive CCD-Based Object Detection</u>

FIG. 40C4

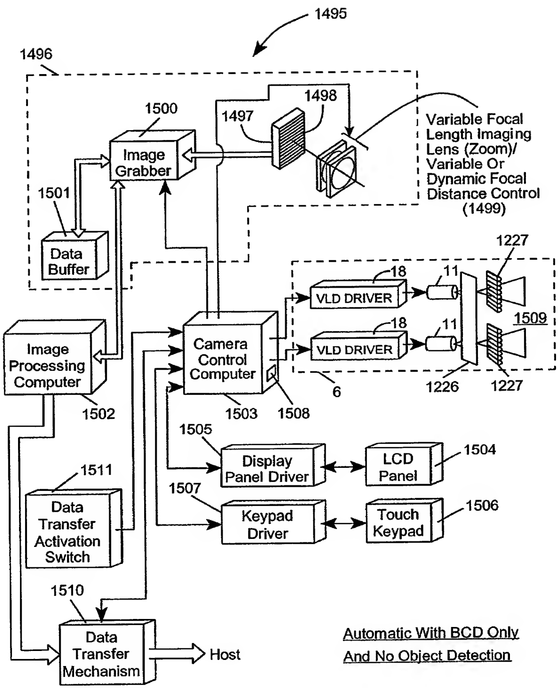

1495
1496
1500
1497
1498
Image Grabber
Variable Focal Length Imaging Lens (Zoom)/ Variable Or Dynamic Focal Distance Control (1499)
1501
Data Buffer
1227
18
11
VLD DRIVER
1509
18
11
VLD DRIVER
Image Processing Computer
Camera Control Computer
6
1226
1227
1502
1503
1508
1505
Display Panel Driver
LCD Panel
1504
1511
1507
Keypad Driver
Touch Keypad
1506
Data Transfer Activation Switch
1510
Data Transfer Mechanism
Host
Automatic With BCD Only And No Object Detection

FIG. 40C5

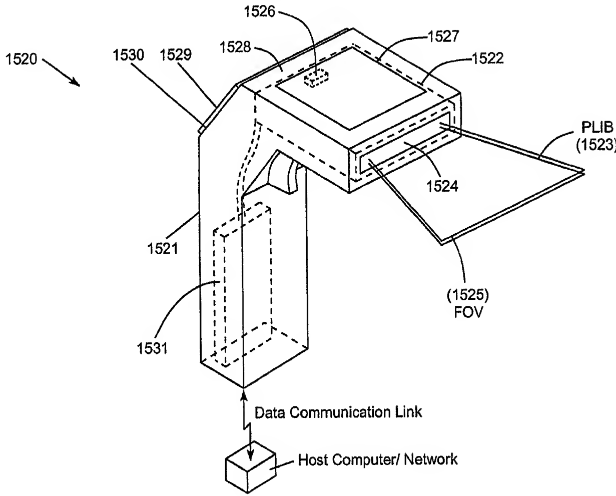
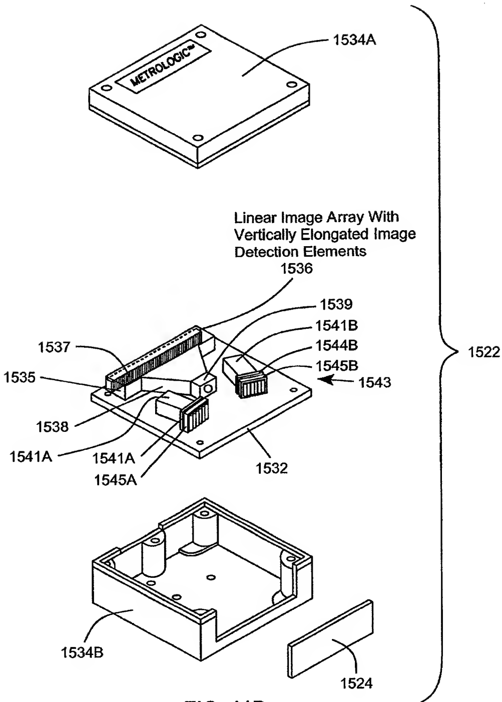

1520
1530
1529
1528
1526
1527
1522
PLIB
(1523)
1524
1521
1531
(1525)
FOV
Data Communication Link
Host Computer/ Network

FIG. 41A



1534A
METROLOGIC™
Linear Image Array With
Vertically Elongated Image
Detection Elements
1536
1539
1541B
1544B
1545B
1543
1537
1535
1538
1541A
1541A
1545A
1532
1522
1534B
1524

FIG. 41B

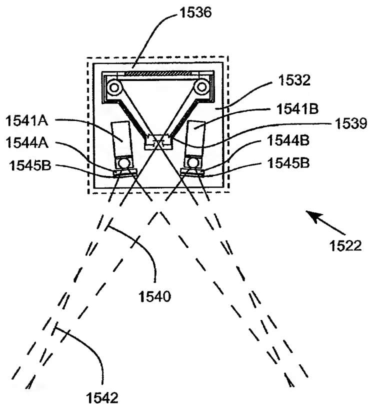


FIG. 41C

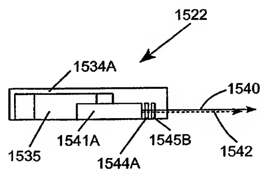


FIG. 41D

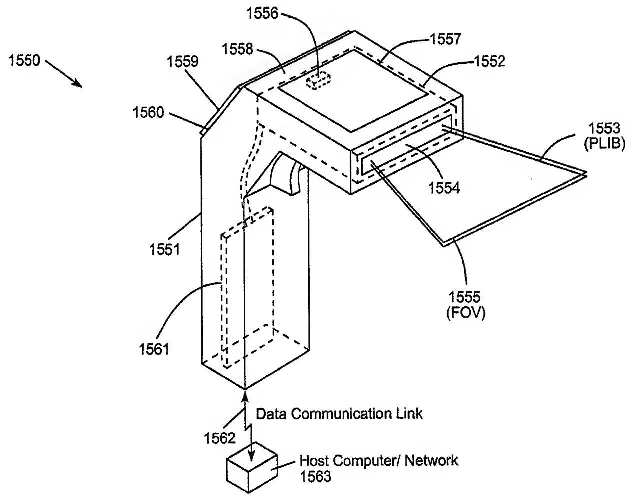

1550
1556
1558
1559
1557
1552
1560
1553
(PLIB)
1554
1551
1555
(FOV)
1561
Data Communication Link
1562
Host Computer/ Network
1563

FIG. 42A

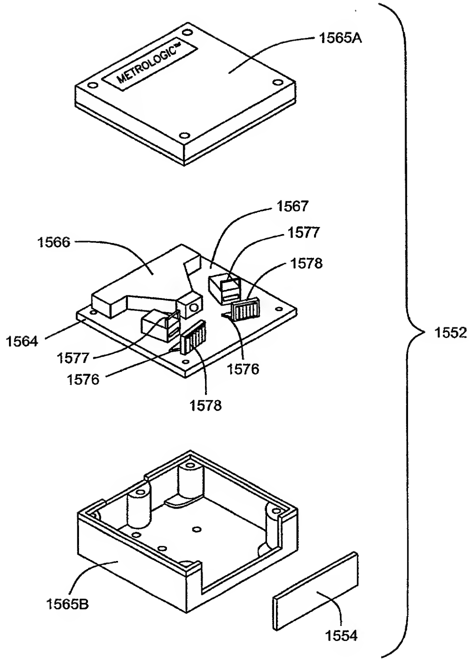

1565A
METROLOGIC™
1567
1577
1566
1578
1552
1564
1577
1576
1576
1578
1565B
1554

FIG. 42B

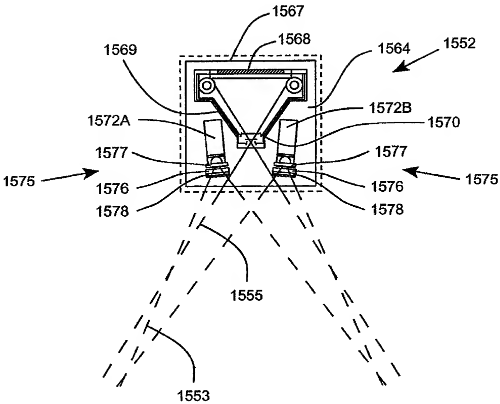


FIG. 42C

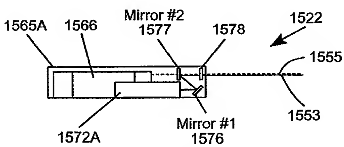


FIG. 42D

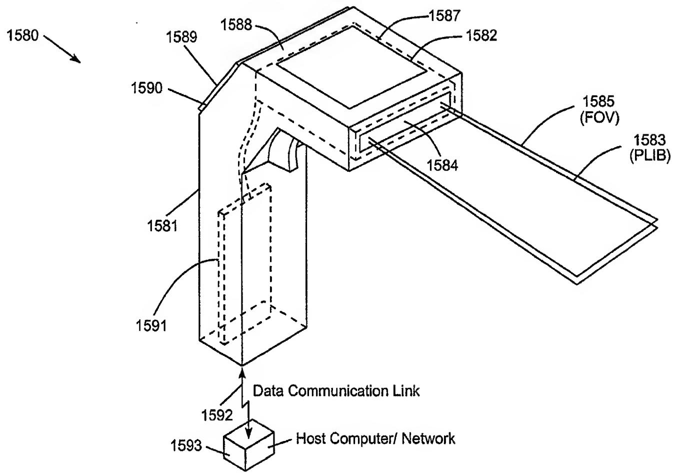

1580
1589
1588
1587
1582
1590
1585
(FOV)
1583
(PLIB)
1584
1581
1591
Data Communication Link
1592
1593
Host Computer/ Network

FIG. 43A

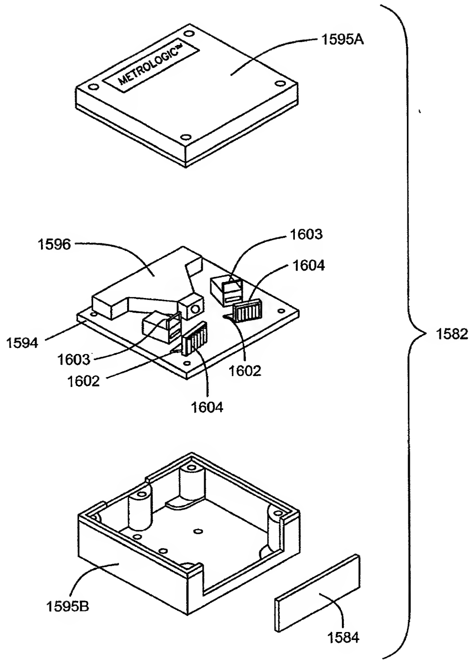

METROLOGIC™
1595A
1596
1603
1604
1594
1603
1602
1602
1604
1582
1595B
1584

FIG. 43B

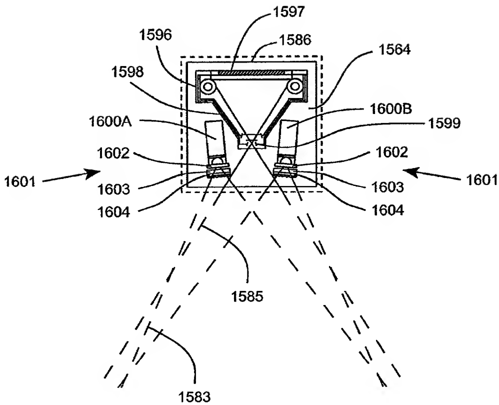


FIG. 43C

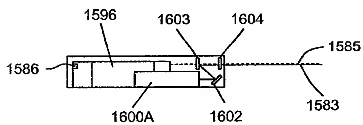


FIG. 43D

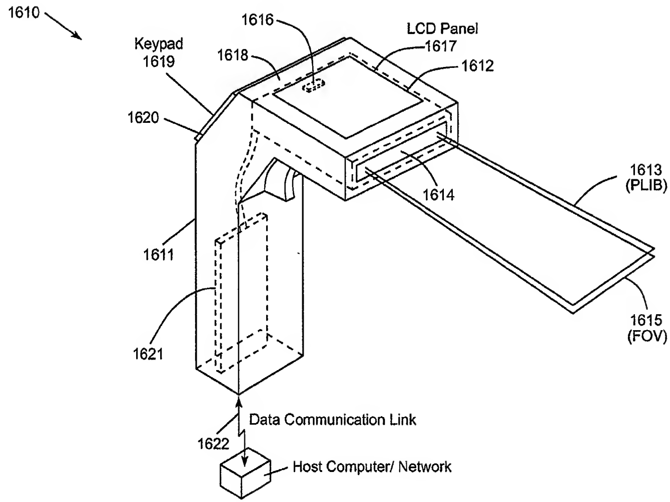

1610
1616
LCD Panel
1617
1612
Keypad
1619
1618
1620
1614
1613
(PLIB)
1611
1615
(FOV)
1621
Data Communication Link
1622
Host Computer/ Network

FIG. 44A

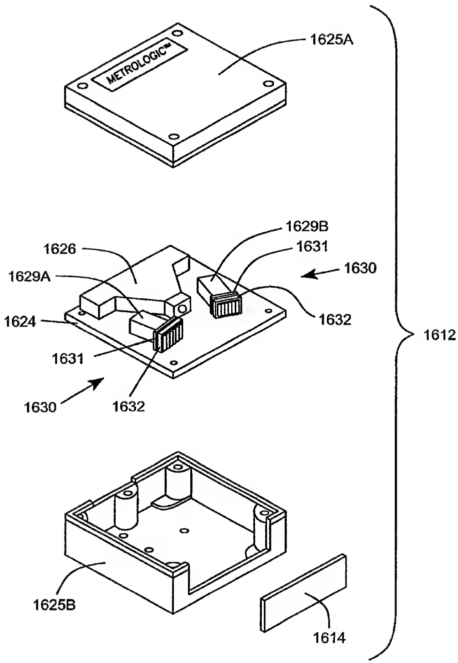

METROLOGIC™
1625A
1629B
1626
1631
1630
1629A
1624
1632
1612
1631
1630
1632
1625B
1614

FIG. 44B

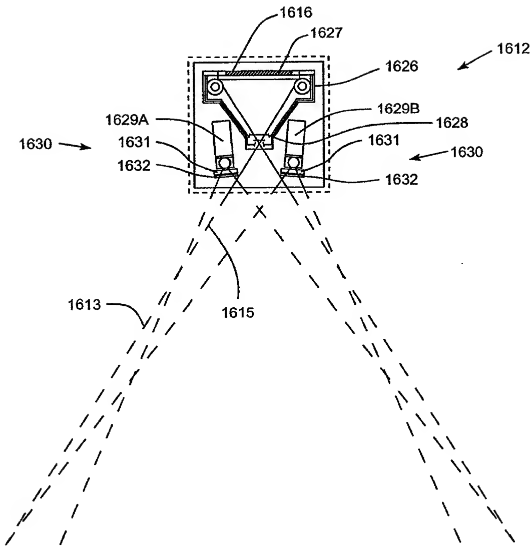

1616
1627
1612
1626
1629B
1629A
1628
1630
1631
1631
1630
1632
1632
1613
1615

FIG. 44C

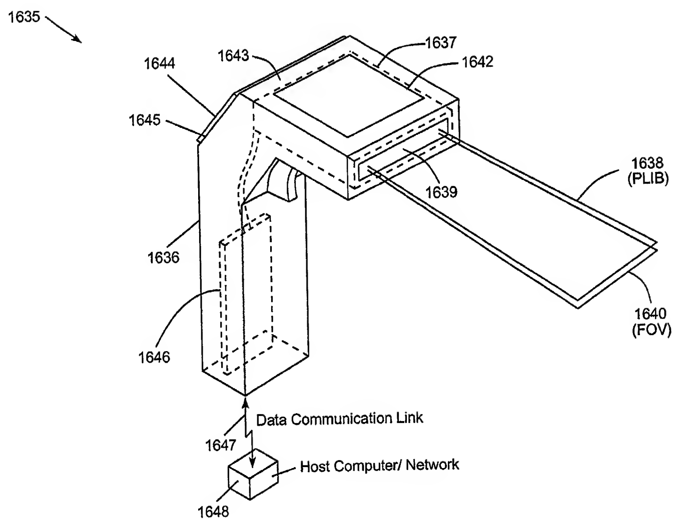

1635
1644
1643
1637
1642
1645
1638
(PLIB)
1639
1636
1640
(FOV)
1646
Data Communication Link
1647
Host Computer/ Network
1648

FIG. 45A

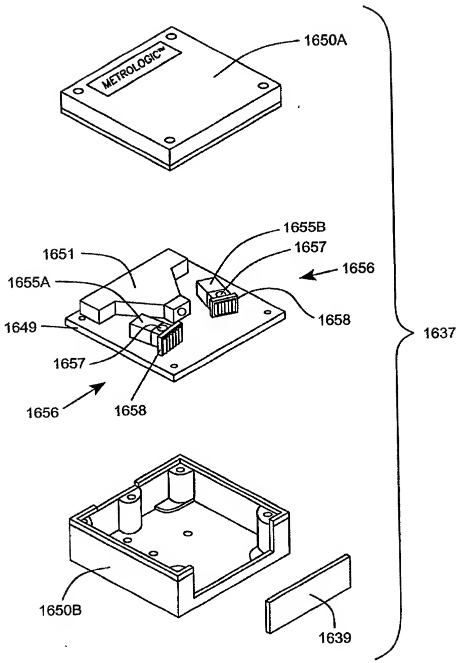

1650A
METROLOGIC™
1655B
1657
1651
1656
1655A
1658
1649
1637
1657
1656
1658
1650B
1639

FIG. 45B

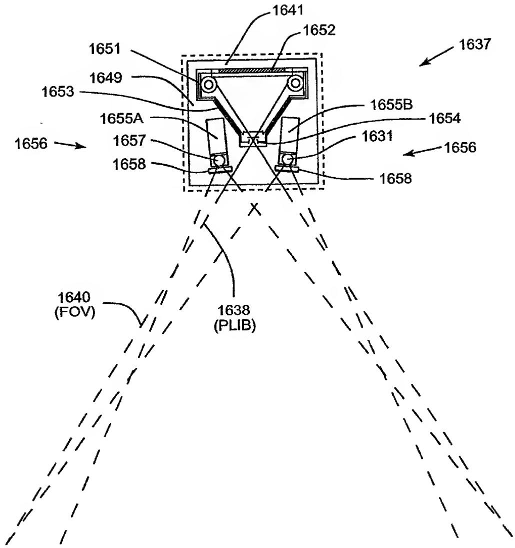
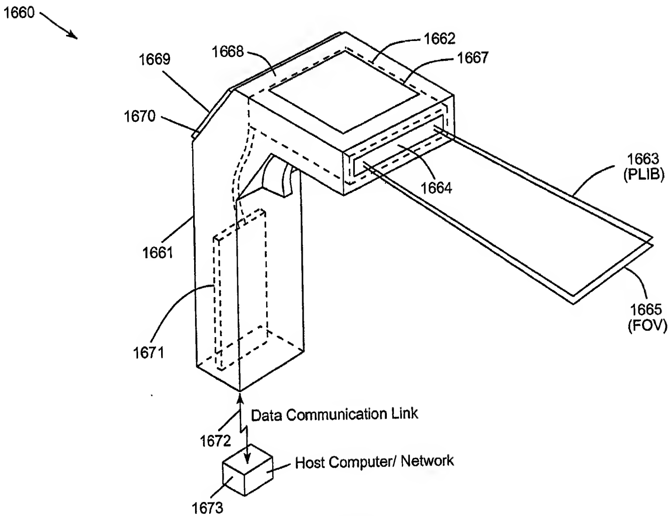

1641
1652
1637
1651
1649
1653
1655B
1655A
1654
1656
1657
1631
1656
1658
1658
1640
(FOV)
1638
(PLIB)

FIG. 45C



1660
1669
1668
1662
1667
1670
1663
(PLIB)
1664
1661
1665
(FOV)
1671
Data Communication Link
1672
Host Computer/ Network
1673

FIG. 46A

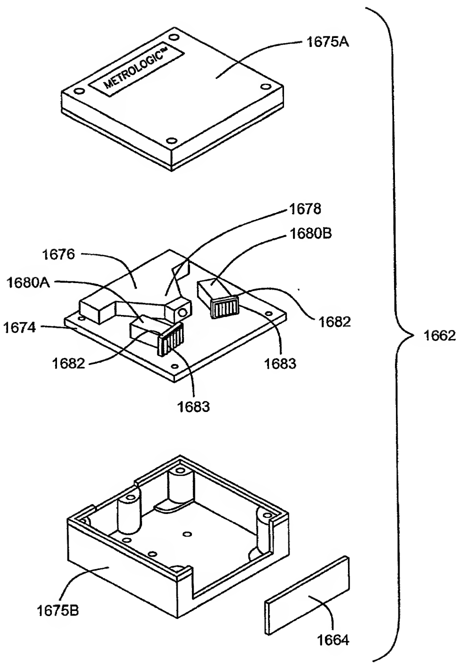

1675A
METROLOGIC™
1678
1680B
1676
1680A
1674
1682
1662
1682
1683
1683
1675B
1664

FIG. 46B

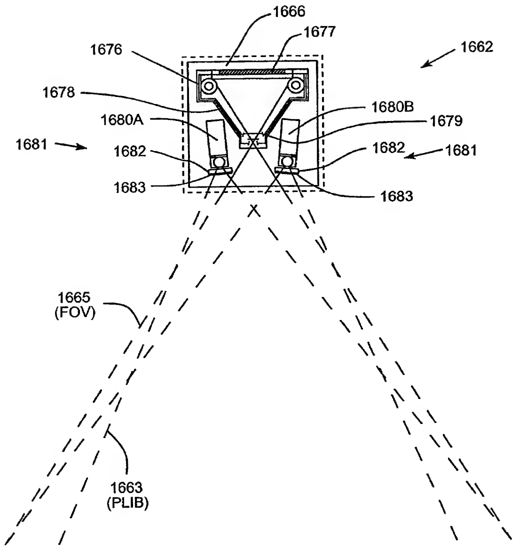

1666
1677
1676
1662
1678
1680B
1680A
1679
1681
1682
1682
1681
1683
1683
1665
(FOV)
1663
(PLIB)

FIG. 46C

20060203.042900

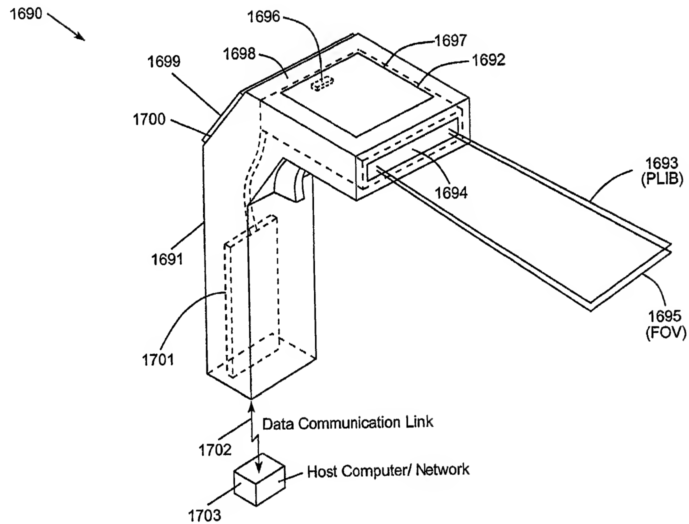


FIG. 47A

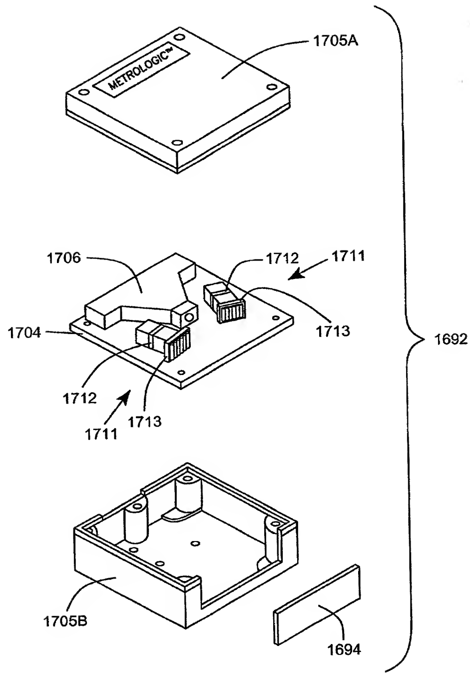

1705A
METROLOGIC™
1706
1712
1711
1704
1713
1692
1712
1713
1711
1705B
1694

FIG. 47B

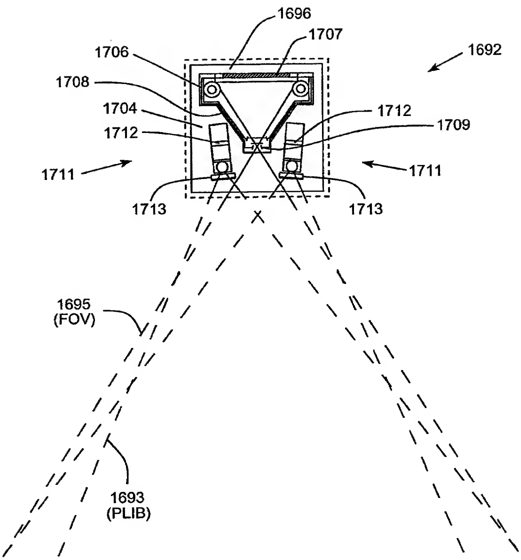

1696
1707
1706
1692
1708
1704
1712
1709
1712
1711
1711
1713
1713
1695
(FOV)
1693
(PLIB)

FIG. 47C

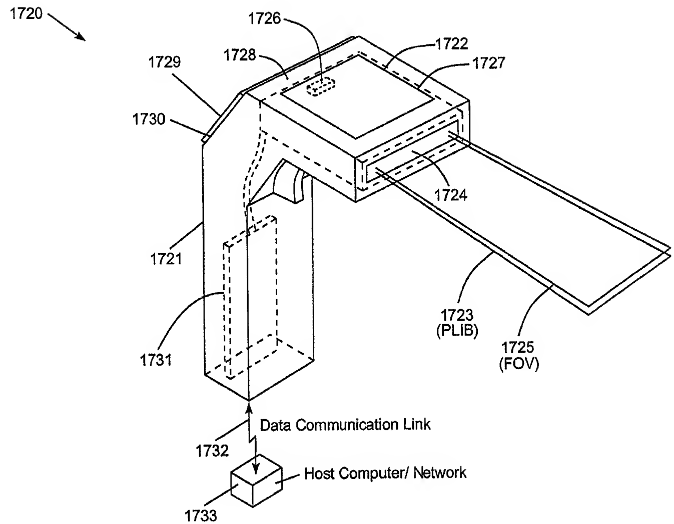

1720
1726
1722
1727
1728
1729
1730
1724
1721
1731
1723
(PLIB)
1725
(FOV)
Data Communication Link
1732
Host Computer/ Network
1733

FIG. 48A

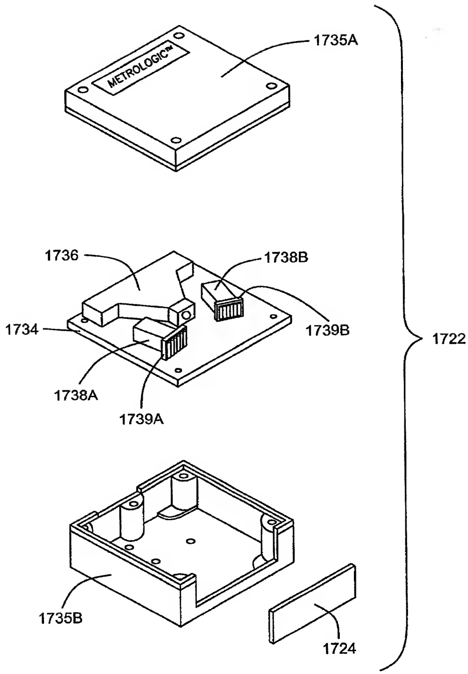

METROLOGIC™
1735A
1736
1738B
1734
1739B
1722
1738A
1739A
1735B
1724

FIG. 48B

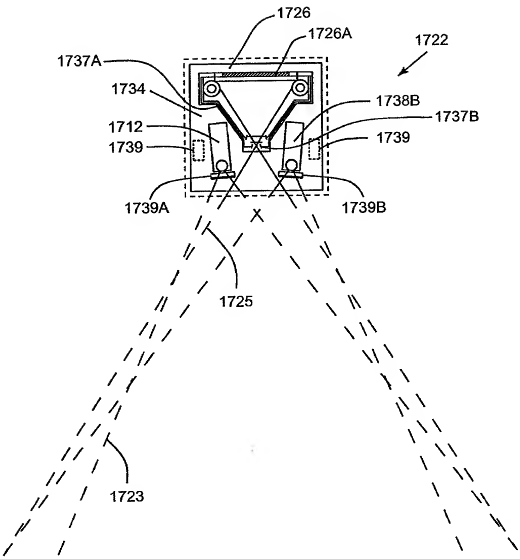

1726
1726A
1722
1737A
1734
1738B
1737B
1712
1739
1739
1739A
1739B
1725
1723

FIG. 48C

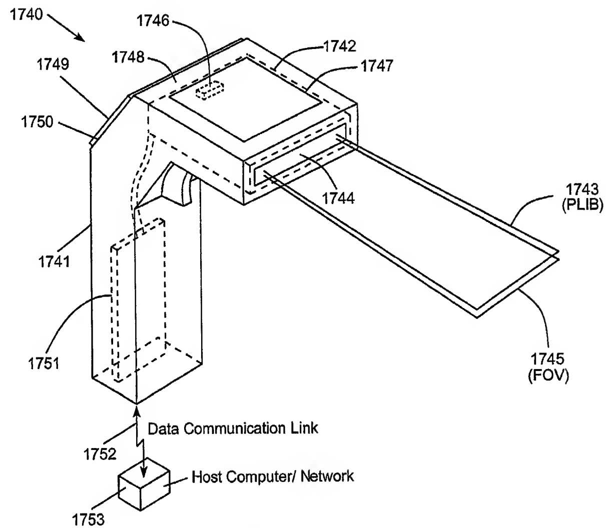

1740
1746
1742
1747
1749
1748
1750
1744
1743
(PLIB)
1741
1751
1745
(FOV)
Data Communication Link
1752
Host Computer/ Network
1753

FIG. 49A

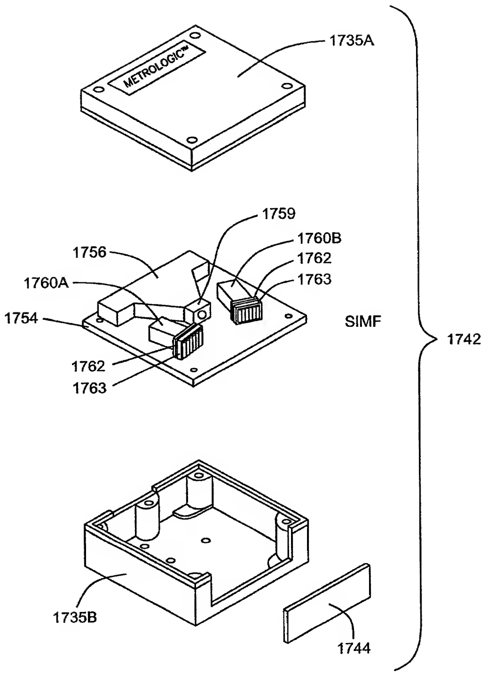


FIG. 49B

40657540 "070502

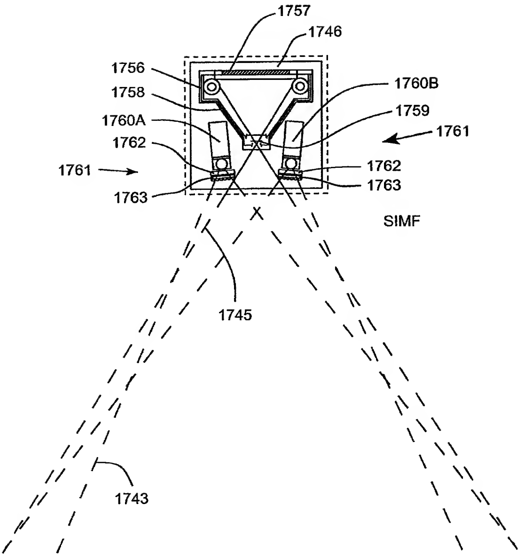

1757
1746
1756
1758
1760A
1762
1761
1763
1760B
1759
1761
1762
1763
X
SIMF
1745
1743

FIG. 49C

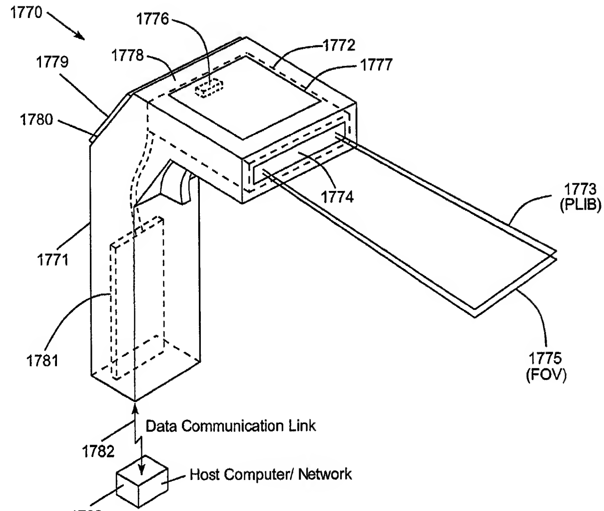

1770
1776
1779
1778
1772
1777
1780
1774
1773
(PLIB)
1771
1781
1775
(FOV)
Data Communication Link
1782
Host Computer/ Network
1783

FIG. 50A

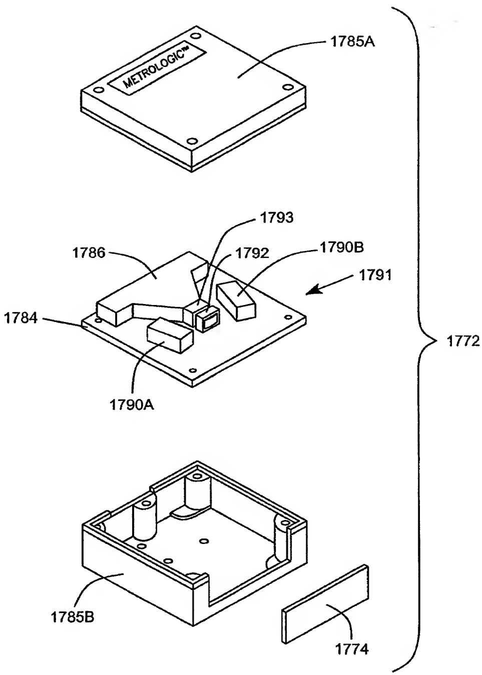

1785A
METROLOGIC™
1793
1786
1792
1790B
1791
1784
1772
1790A
1785B
1774

FIG. 50B

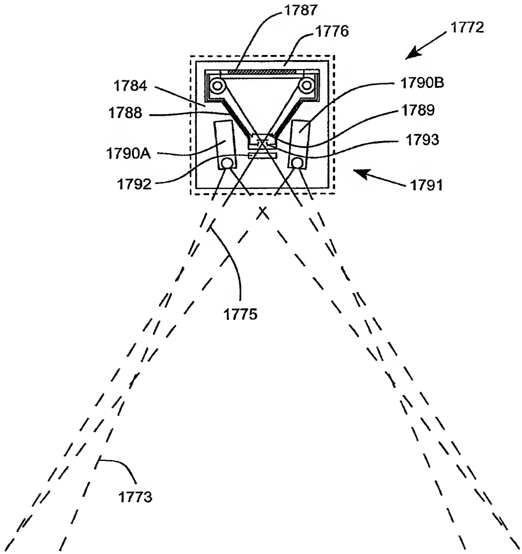

1787
1776
1772
1784
1790B
1788
1789
1793
1790A
1792
1791
1775
1773

FIG. 50C

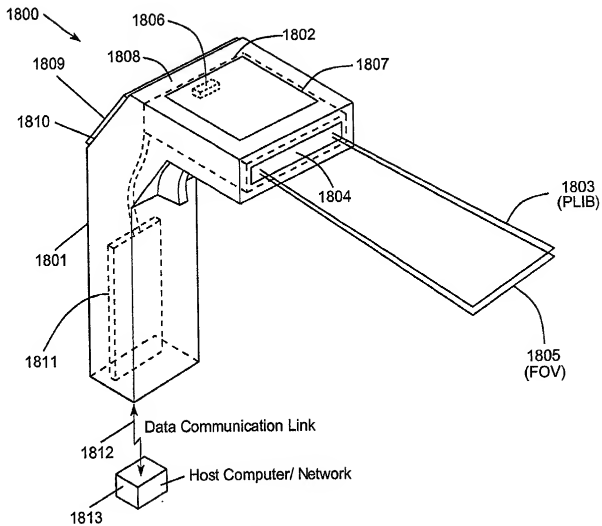

1800
1806
1802
1809
1808
1807
1810
1804
1803
(PLIB)
1801
1811
1805
(FOV)
Data Communication Link
1812
Host Computer/ Network
1813

FIG. 51A

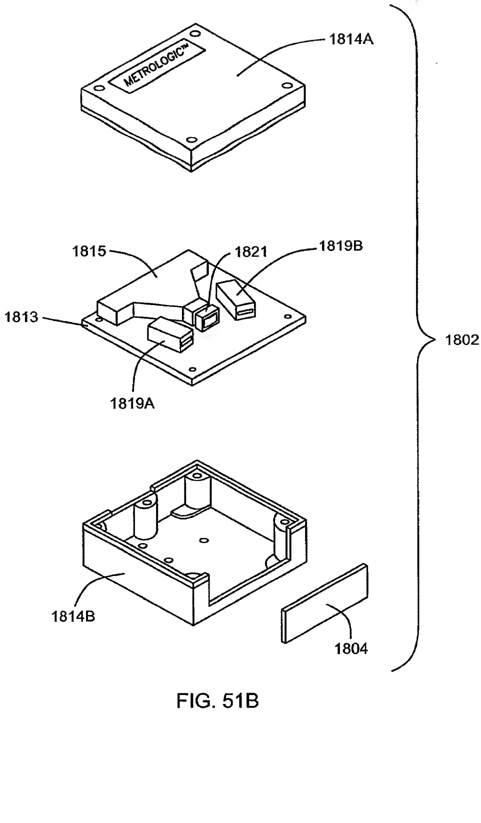


FIG. 51B

10057649.062902

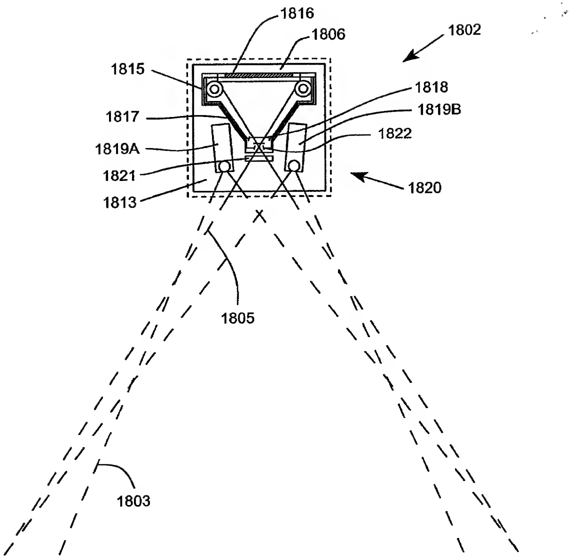

1816
1806
1802
1815
1818
1819B
1817
1822
1819A
1821
1820
1813
1805
1803

FIG. 51C

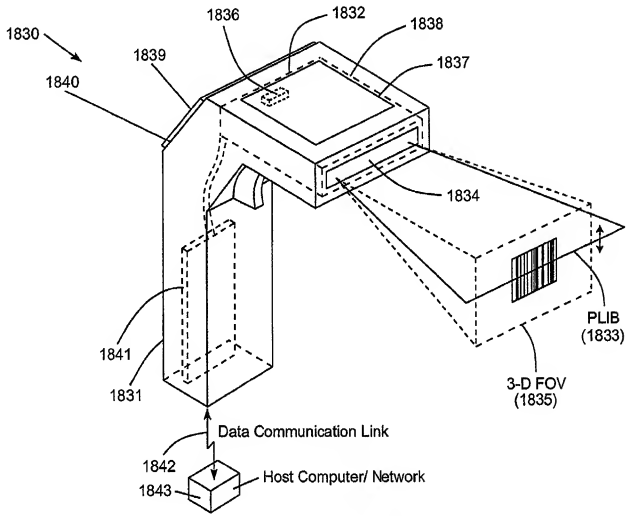

1830
1836
1832
1838
1839
1840
1837
1834
1841
1831
PLIB
(1833)
3-D FOV
(1835)
Data Communication Link
1842
1843
Host Computer/ Network

FIG. 52A

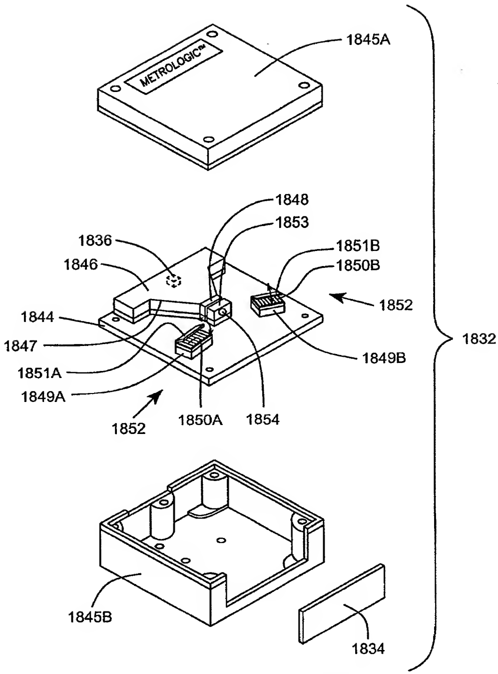


Fig. 1I3A-3B

FIG. 52B

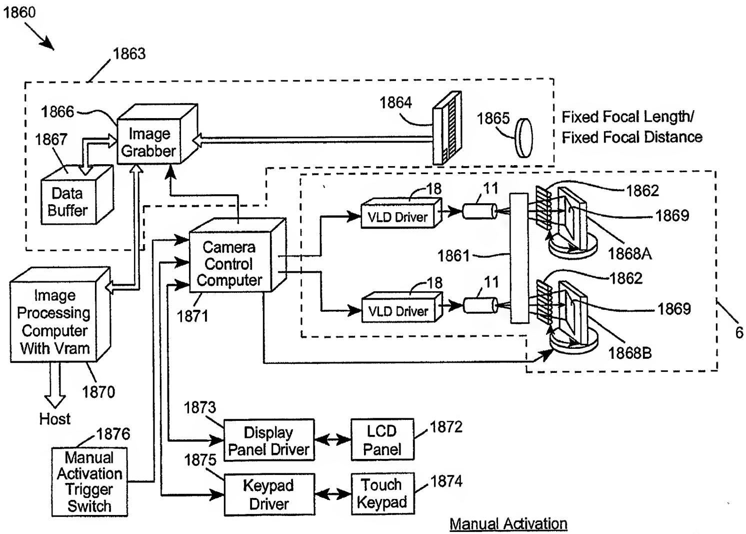

1860
1863
1866
1867
Image Grabber
Data Buffer
1864
1865
Fixed Focal Length/
Fixed Focal Distance
18
11
1862
1869
VLD Driver
1868A
1861
1862
18
11
VLD Driver
1869
6
1868B
Camera Control Computer
1871
Image Processing Computer With Vram
1870
Host
1876
Manual Activation Trigger Switch
1873
Display Panel Driver
LCD Panel
1872
1875
Keypad Driver
Touch Keypad
1874
Manual Activation

FIG. 53A1

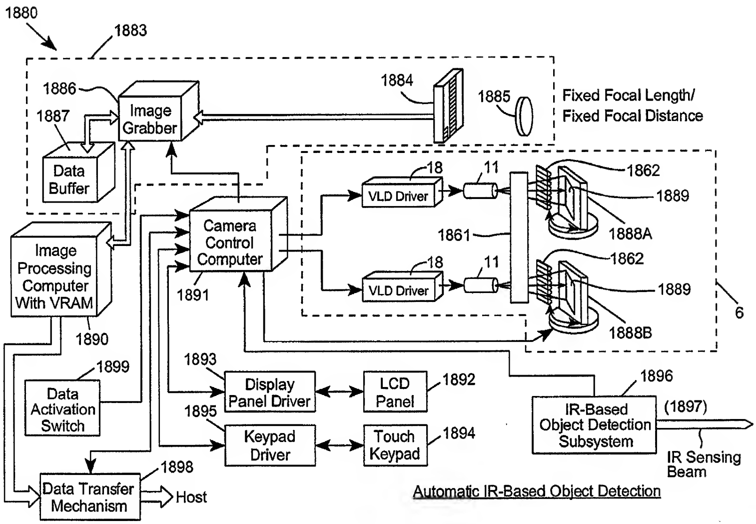

1880
1883
1886
1887
Image Grabber
Data Buffer
1884
1885
Fixed Focal Length/
Fixed Focal Distance
Image Processing Computer With VRAM
1890
Camera Control Computer
1891
18
VLD Driver
11
1861
1862
1889
1888A
1888B
6
1899
Data Activation Switch
1893
Display Panel Driver
LCD Panel
1892
1895
Keypad Driver
Touch Keypad
1894
1896
IR-Based Object Detection Subsystem
(1897)
IR Sensing Beam
1898
Data Transfer Mechanism
Host
Automatic IR-Based Object Detection

FIG. 53A2

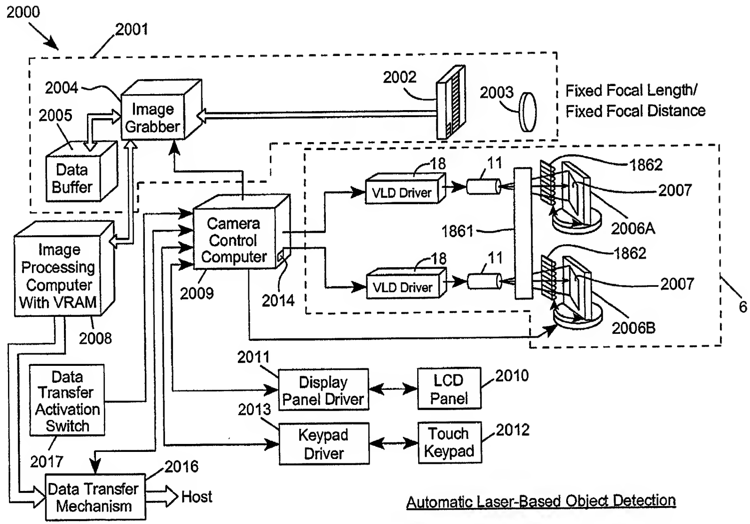

2000
2001
2004
2005
Image Grabber
Data Buffer
2002
2003
Fixed Focal Length/ Fixed Focal Distance
Image Processing Computer With VRAM
2008
Camera Control Computer
2009
2014
18
VLD Driver
11
1861
1862
2007
2006A
2006B
6
Data Transfer Activation Switch
2017
Display Panel Driver
2011
LCD Panel
2010
Keypad Driver
2013
Touch Keypad
2012
Data Transfer Mechanism
2016
Host
Automatic Laser-Based Object Detection

FIG. 53A3

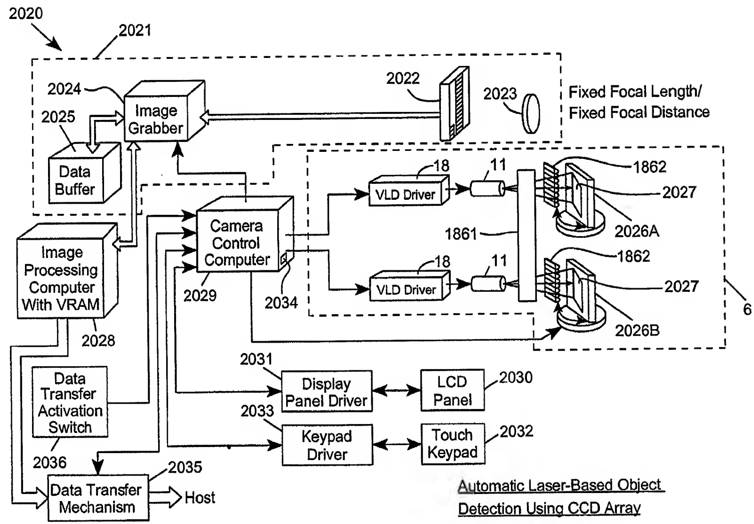

2020
2021
2024
2025
Image Grabber
Data Buffer
2022
2023
Fixed Focal Length/
Fixed Focal Distance
Image Processing Computer With VRAM
2028
Camera Control Computer
2029
2034
18
VLD Driver
11
1861
1862
2027
2026A
2026B
6
2031
Display Panel Driver
LCD Panel
2030
2033
Keypad Driver
Touch Keypad
2032
Data Transfer Activation Switch
2036
Data Transfer Mechanism
2035
Host
Automatic Laser-Based Object
Detection Using CCD Array

FIG. 53A4

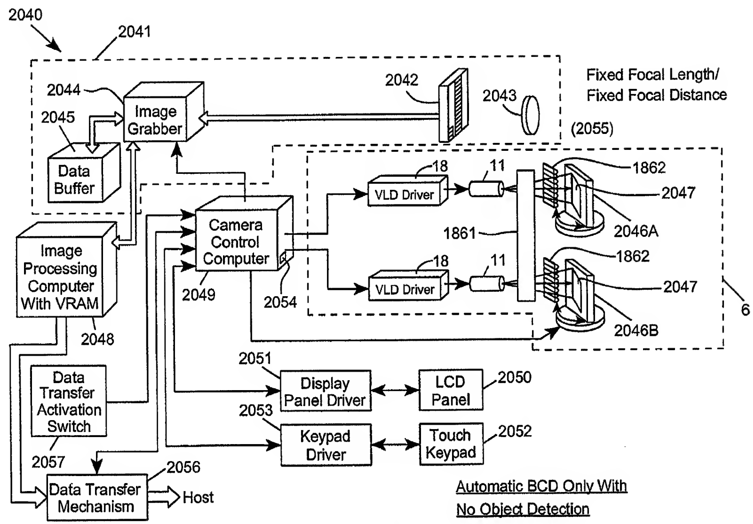

2040
2041
2044
2045
Image Grabber
Data Buffer
2042
2043
Fixed Focal Length/
Fixed Focal Distance
(2055)
18
11
VLD Driver
1862
2047
2046A
1861
2046B
6
Camera Control Computer
2049
2054
Image Processing Computer With VRAM
2048
Data Transfer Activation Switch
2057
Data Transfer Mechanism
2056
Host
2051
Display Panel Driver
LCD Panel
2050
2053
Keypad Driver
Touch Keypad
2052
Automatic BCD Only With
No Object Detection

FIG. 53A5

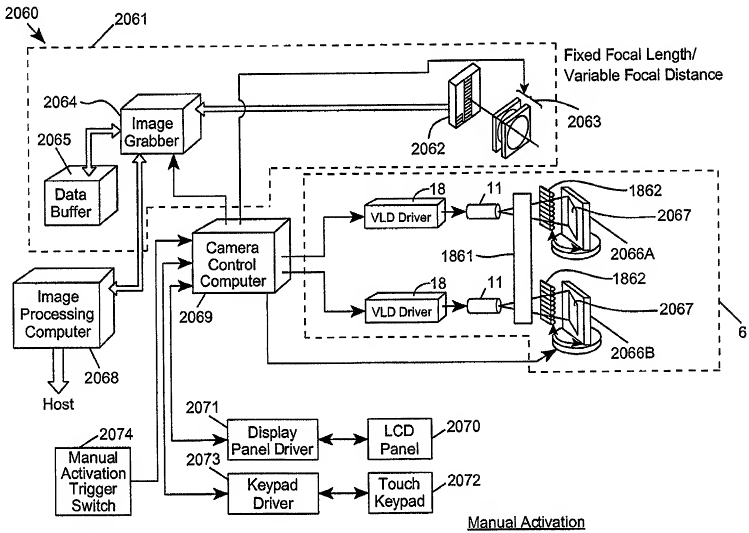
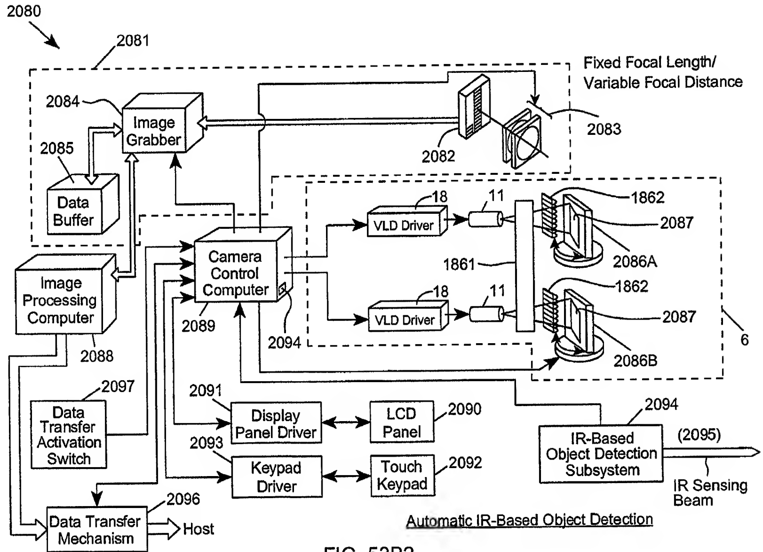
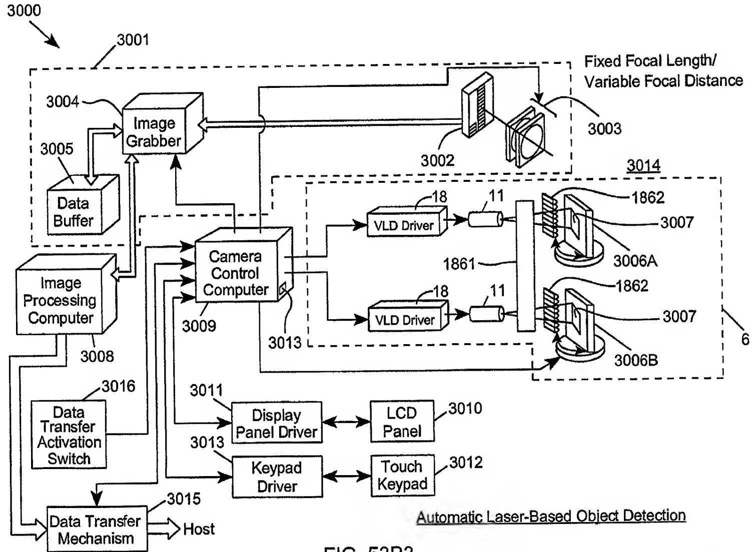

2060
2061
Fixed Focal Length/
Variable Focal Distance
2064
Image Grabber
2065
Data Buffer
2062
2063
18
11
1862
2067
VLD Driver
2066A
1861
Camera Control Computer
18
11
1862
VLD Driver
2067
6
Image Processing Computer
2069
2066B
2068
Host
2071
Display Panel Driver
LCD Panel
2070
2074
Manual Activation Trigger Switch
2073
Keypad Driver
Touch Keypad
2072
Manual Activation

FIG. 53B1



2080
2081
2084
Image Grabber
2085
Data Buffer
Fixed Focal Length/
Variable Focal Distance
2083
2082
Image Processing Computer
2088
Camera Control Computer
2089
2094
18
VLD Driver
11
1862
2087
2086A
1861
18
VLD Driver
11
1862
2087
2086B
6
2097
Data Transfer Activation Switch
2091
Display Panel Driver
LCD Panel
2090
2093
Keypad Driver
Touch Keypad
2092
2094
IR-Based Object Detection Subsystem
(2095)
IR Sensing Beam
2096
Data Transfer Mechanism
Host
Automatic IR-Based Object Detection

FIG. 53B2



<u>Automatic Laser-Based Object Detection</u>

FIG. 53B3

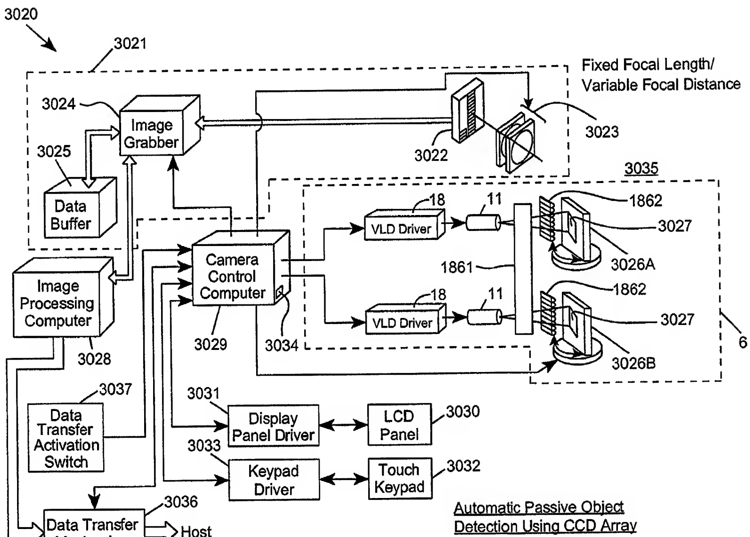

3020
3021
3024
Image Grabber
3025
Data Buffer
Image Processing Computer
3028
3037
Data Transfer Activation Switch
Data Transfer Mechanism
3036
Host
Camera Control Computer
3029
3034
3031
Display Panel Driver
3033
Keypad Driver
LCD Panel
3030
Touch Keypad
3032
Fixed Focal Length/
Variable Focal Distance
3022
3023
3035
18
VLD Driver
11
1861
1862
3027
3026A
3026B
6
Automatic Passive Object
Detection Using CCD Array

FIG. 53B4

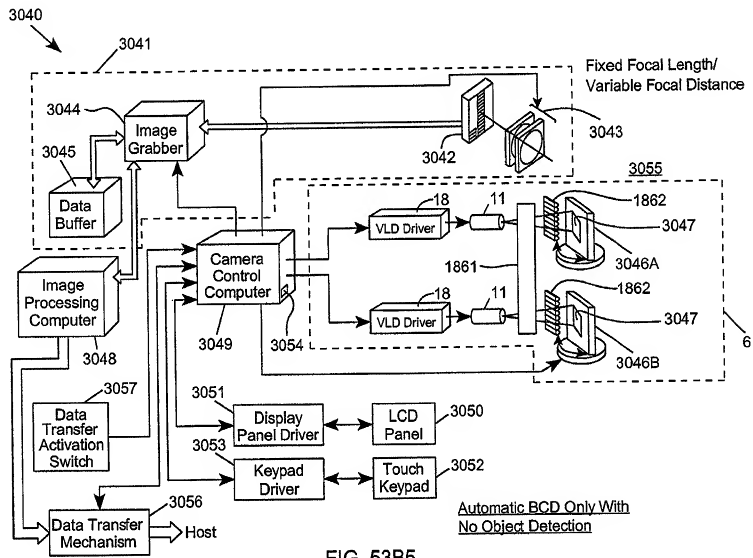

3040
3041
Fixed Focal Length/
Variable Focal Distance
3044
Image
Grabber
3045
Data
Buffer
3042
3043
3055
18
11
1862
VLD Driver
3047
Camera
Control
Computer
1861
3046A
Image
Processing
Computer
18
11
1862
VLD Driver
3047
3049
3054
6
3048
3046B
3057
3051
Display
Panel Driver
LCD
Panel
3050
Data
Transfer
Activation
Switch
3053
Keypad
Driver
Touch
Keypad
3052
3056
Data Transfer
Mechanism
Host
Automatic BCD Only With
No Object Detection

FIG. 53B5

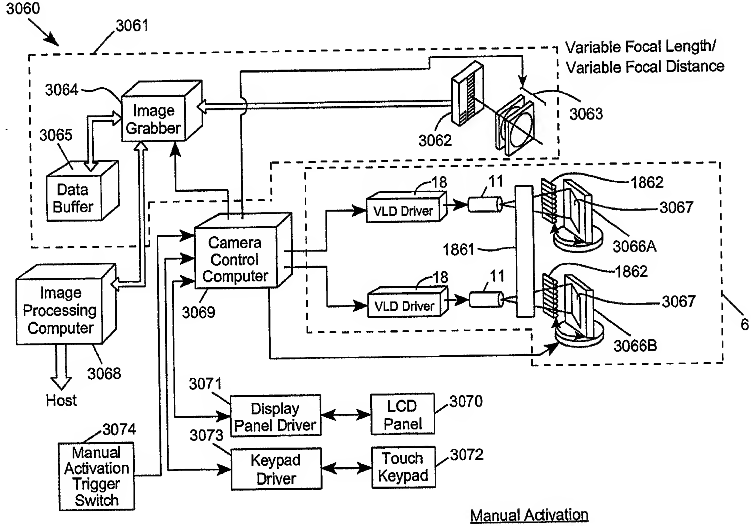

3060
3061
Variable Focal Length/
Variable Focal Distance
3064
Image Grabber
3065
Data Buffer
3062
3063
18
11
VLD Driver
1862
3067
3066A
1861
VLD Driver
1862
3067
3066B
6
Camera Control Computer
3069
Image Processing Computer
3068
Host
3071
Display Panel Driver
LCD Panel
3070
3074
Manual Activation Trigger Switch
3073
Keypad Driver
Touch Keypad
3072
Manual Activation

FIG. 53C1

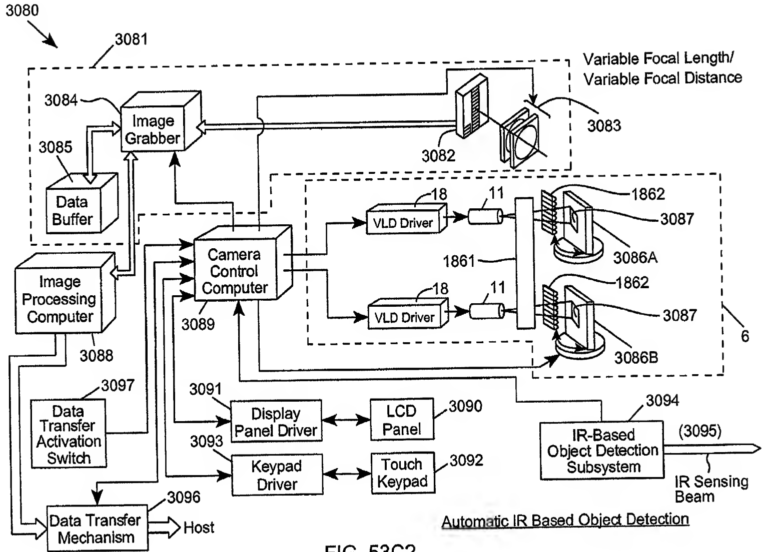
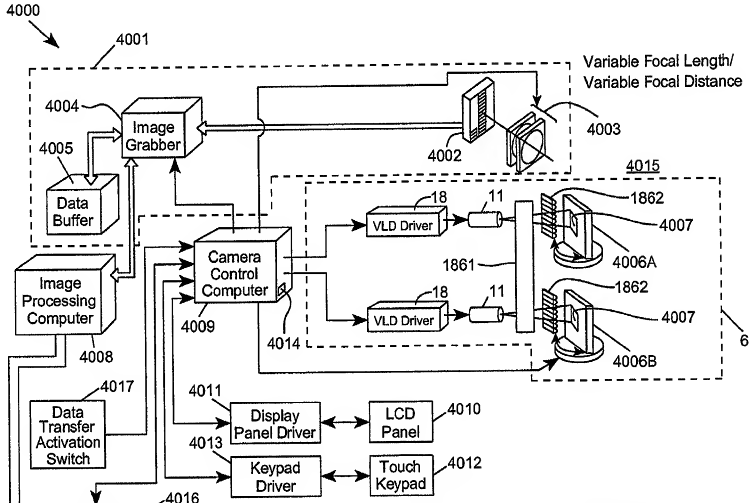

3080
3081
Variable Focal Length/
Variable Focal Distance
3084
Image Grabber
3085
Data Buffer
3082
3083
Image Processing Computer
3088
Camera Control Computer
3089
18
VLD Driver
11
1862
3087
3086A
1861
18
VLD Driver
11
1862
3087
3086B
6
3097
Data Transfer Activation Switch
3091
Display Panel Driver
LCD Panel
3090
3093
Keypad Driver
Touch Keypad
3092
3094
IR-Based Object Detection Subsystem
(3095)
IR Sensing Beam
3096
Data Transfer Mechanism
Host
Automatic IR Based Object Detection

FIG. 53C2



Automatic Laser Based Object Detection

FIG. 53C3

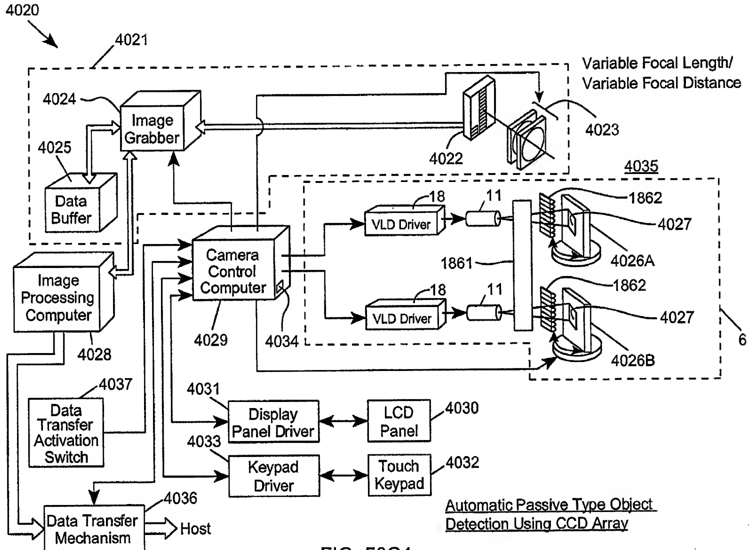

4020
4021
Variable Focal Length/
Variable Focal Distance
4024
Image Grabber
4025
Data Buffer
4023
4022
4035
18
11
1862
VLD Driver
4027
Camera Control Computer
1861
4026A
1862
Image Processing Computer
18
11
VLD Driver
4027
6
4029
4034
4028
4026B
4037
Data Transfer Activation Switch
4031
Display Panel Driver
LCD Panel
4030
4033
Keypad Driver
Touch Keypad
4032
4036
Data Transfer Mechanism
Host
Automatic Passive Type Object
Detection Using CCD Array

FIG. 53C4

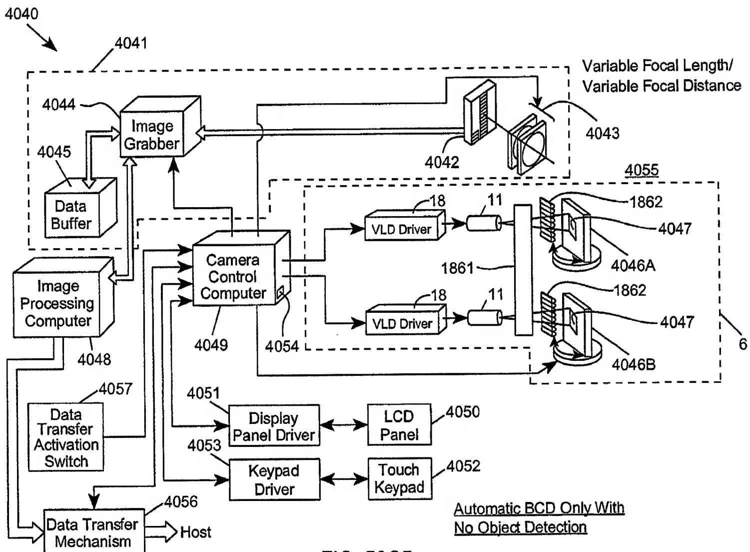

4040
4041
Variable Focal Length/
Variable Focal Distance
4044
Image Grabber
4045
Data Buffer
4042
4043
4055
Image Processing Computer
4048
Camera Control Computer
4049
4054
VLD Driver
18
11
1861
1862
4047
4046A
VLD Driver
18
11
1862
4047
4046B
6
4057
Data Transfer Activation Switch
4051
Display Panel Driver
LCD Panel
4050
4053
Keypad Driver
Touch Keypad
4052
4056
Data Transfer Mechanism
Host
Automatic BCD Only With
No Object Detection

FIG. 53C5

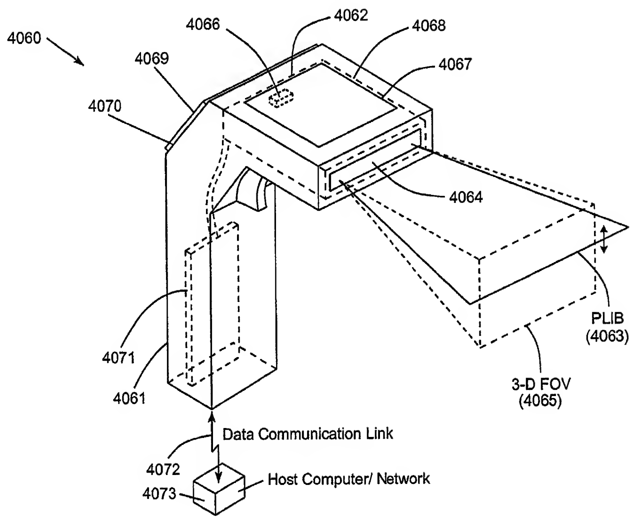

4060
4066
4062
4068
4069
4067
4070
4064
4071
4061
PLIB
(4063)
3-D FOV
(4065)
Data Communication Link
4072
4073
Host Computer/ Network

FIG. 54A

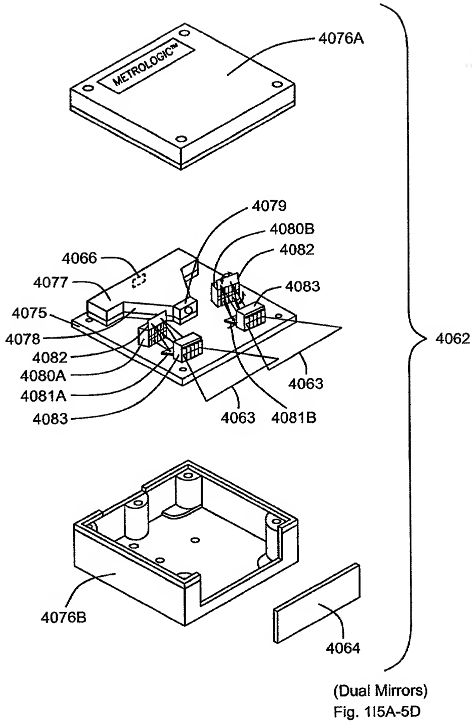

METROLOGIC™
4076A
4079
4080B
4082
4066
4077
4083
4075
4078
4082
4080A
4081A
4083
4063
4063
4081B
4062
4076B
4064
(Dual Mirrors)
Fig. 115A-5D

FIG. 54B

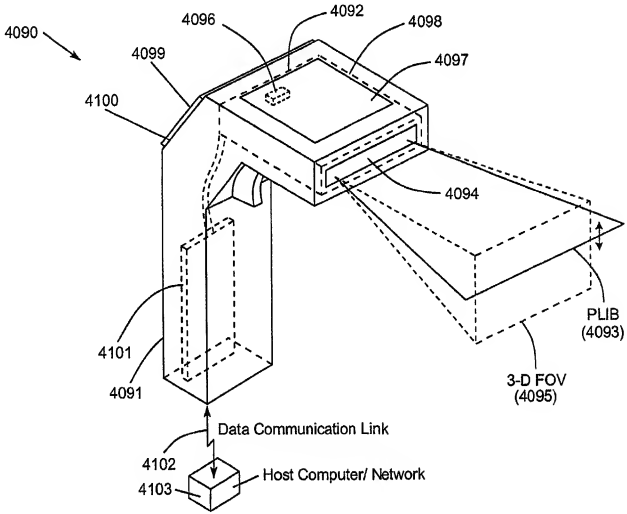
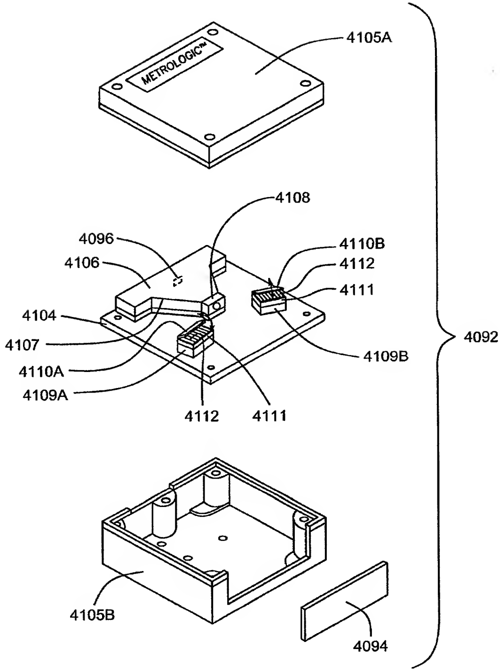

4090
4096
4092
4098
4099
4097
4100
4094
4101
4091
PLIB
(4093)
3-D FOV
(4095)
Data Communication Link
4102
4103
Host Computer/ Network

FIG. 55A



Bragg Cell
Fig. 1I6A-6B

FIG. 55B

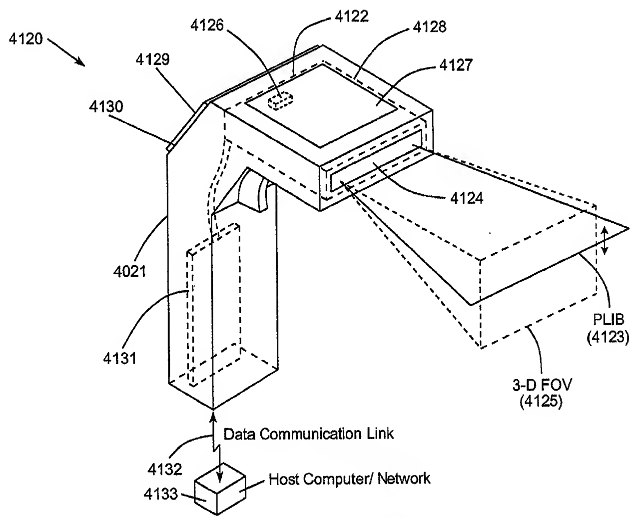
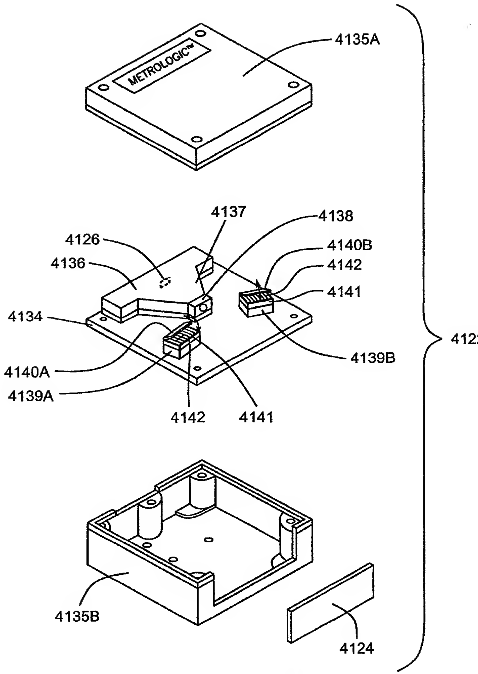

4120
4126
4122
4128
4129
4127
4130
4124
4021
4131
PLIB
(4123)
3-D FOV
(4125)
Data Communication Link
4132
4133
Host Computer/ Network

FIG. 56A



DM
Fig. 1I7A-7B

FIG. 56B

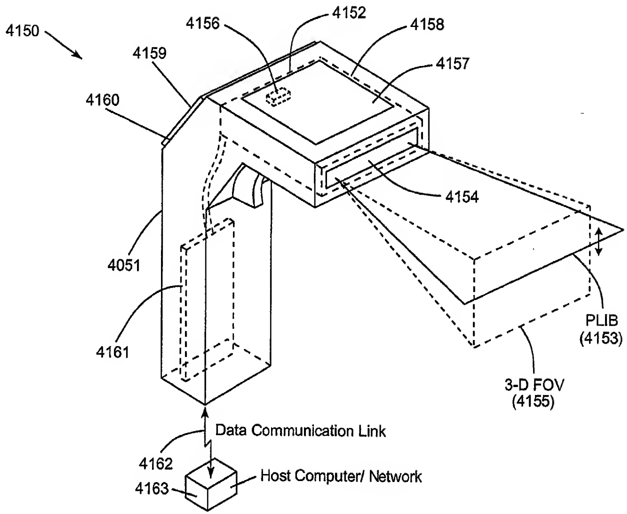

4150
4156
4152
4158
4159
4157
4160
4154
4051
4161
PLIB
(4153)
3-D FOV
(4155)
Data Communication Link
4162
Host Computer/ Network
4163

FIG. 57A

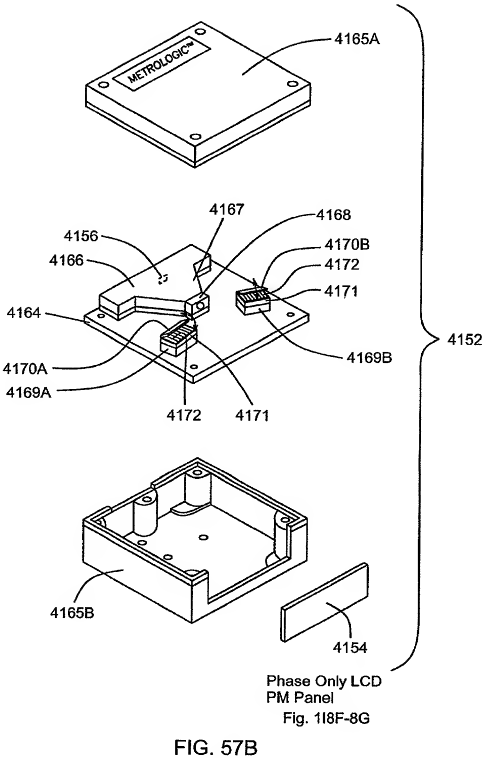

4165A
METROLOGIC™
4167
4168
4156
4170B
4166
4172
4171
4164
4152
4169B
4170A
4169A
4172
4171
4165B
4154
Phase Only LCD
PM Panel
Fig. 1I8F-8G

FIG. 57B

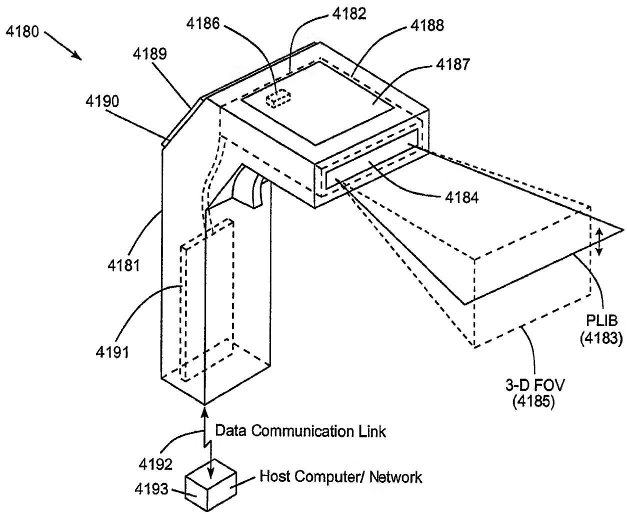
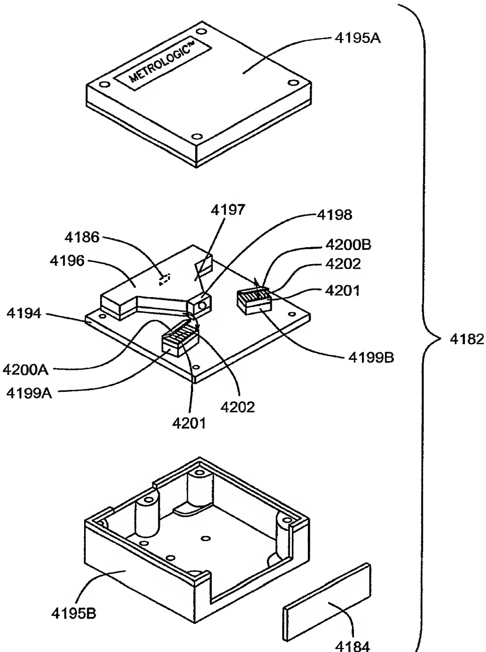

4180
4182
4186
4188
4187
4189
4190
4184
4181
4191
PLIB
(4183)
3-D FOV
(4185)
Data Communication Link
4192
Host Computer/ Network
4193

FIG. 58A



HS Optical Shutter
Fig. 1I14A-14B

FIG. 58B

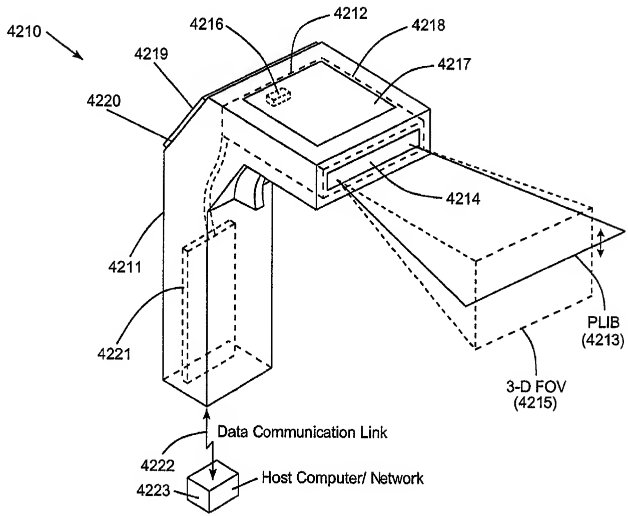
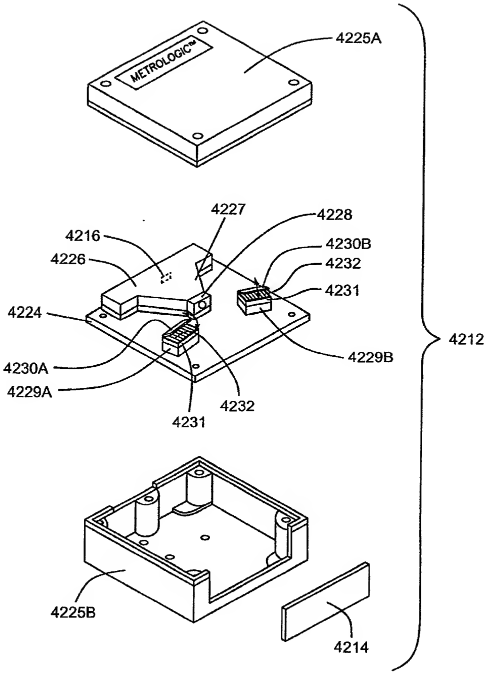

4210
4216
4212
4218
4219
4217
4220
4214
4211
4221
PLIB
(4213)
3-D FOV
(4215)
Data Communication Link
4222
4223
Host Computer/ Network

FIG. 59A



MLLD

Fig. 1I15A-15B

FIG. 59B

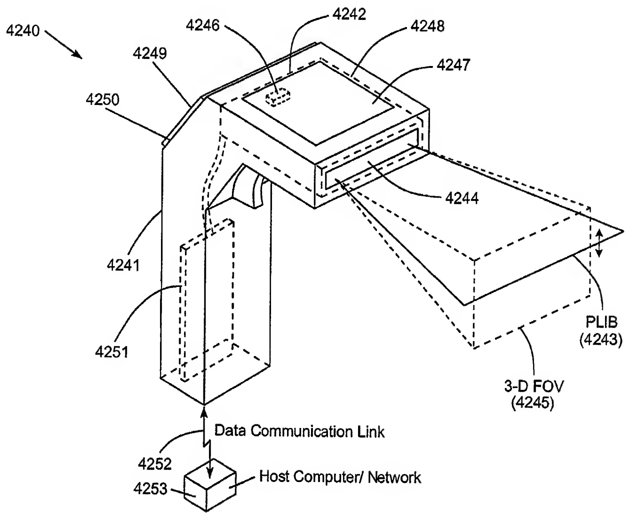
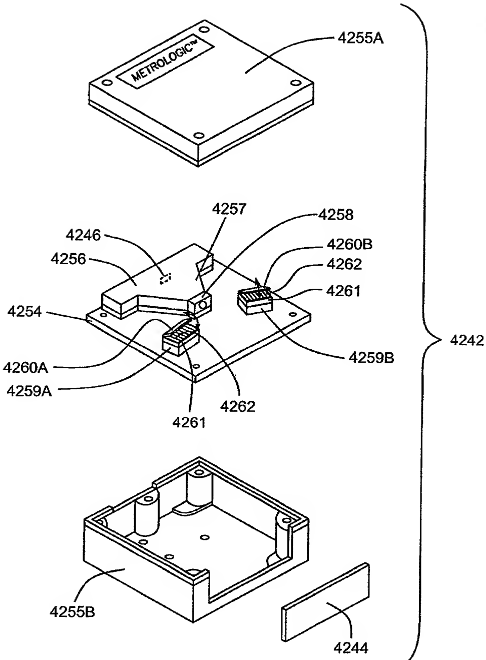

4240
4246
4242
4248
4249
4247
4250
4244
4241
4251
PLIB
(4243)
3-D FOV
(4245)
Data Communication Link
4252
4253
Host Computer/ Network

FIG. 60A



Etalon (Temp. Phase Mod.)
Fig. 1I17A-17B

FIG. 60B

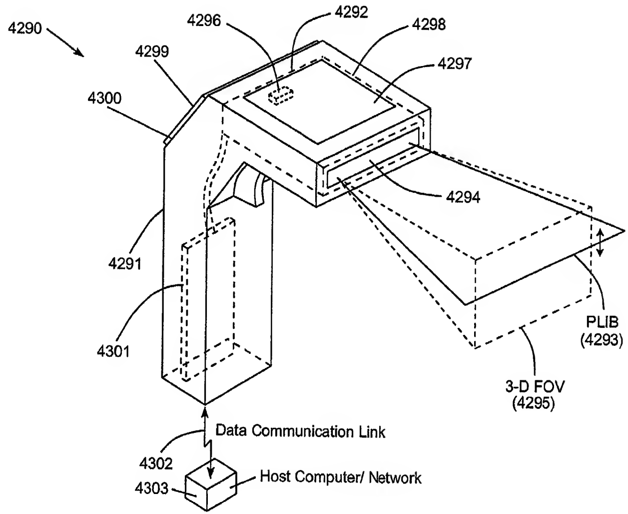
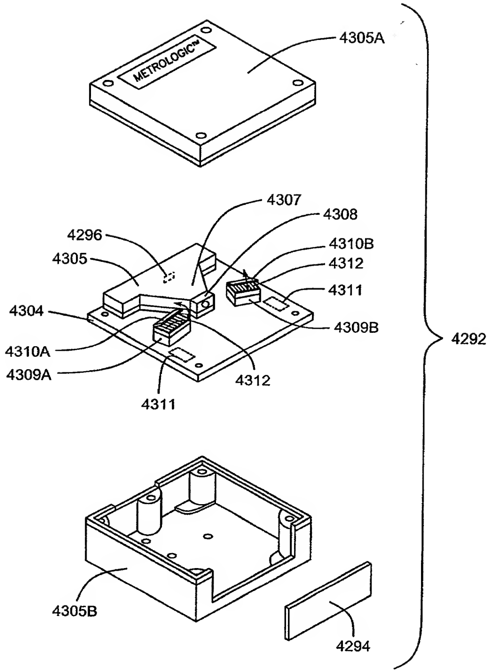

4290
4296
4292
4298
4297
4299
4300
4294
4291
4301
PLIB
(4293)
3-D FOV
(4295)
Data Communication Link
4302
4303
Host Computer/ Network

FIG. 61A



Mode Hopping
Fig. 1I19A-19B

FIG. 61B

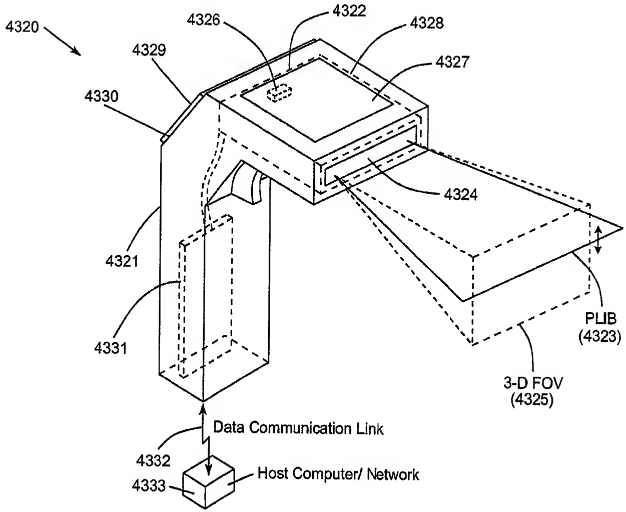
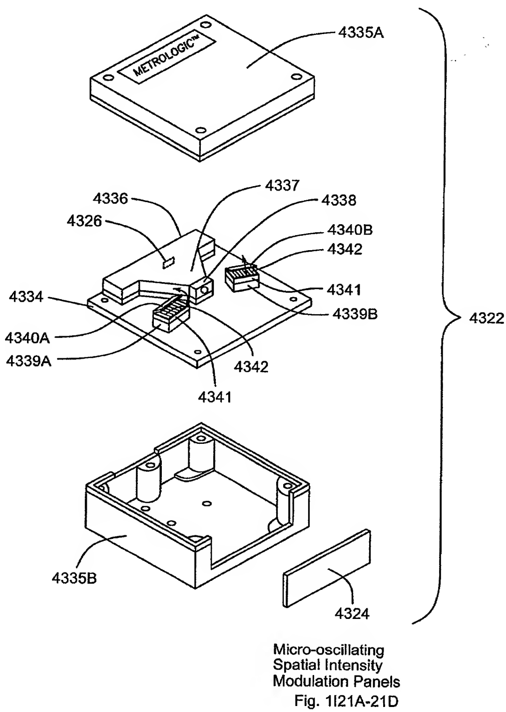

4320
4326
4322
4328
4329
4327
4330
4324
4321
4331
PLIB
(4323)
3-D FOV
(4325)
Data Communication Link
4332
Host Computer/ Network
4333

FIG. 62A



METROLOGIC™
4335A
4337
4336
4338
4326
4340B
4342
4341
4334
4339B
4322
4340A
4339A
4342
4341
4335B
4324
Micro-oscillating
Spatial Intensity
Modulation Panels
Fig. 1I21A-21D

FIG. 62B

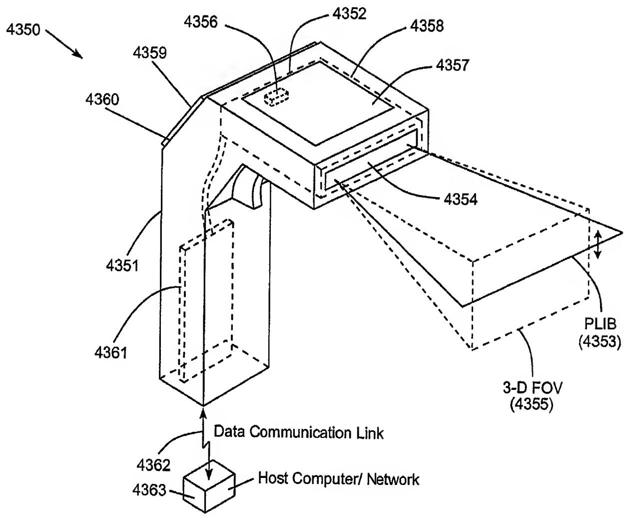
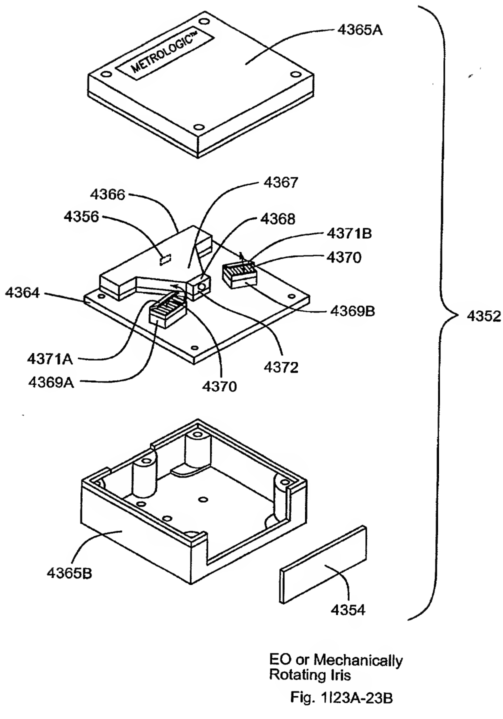

4350
4356
4352
4358
4359
4357
4360
4354
4351
4361
PLIB
(4353)
3-D FOV
(4355)
Data Communication Link
4362
4363
Host Computer/ Network

FIG. 63A



4365A
METROLOGIC™
4367
4366
4356
4368
4371B
4370
4364
4369B
4352
4371A
4372
4369A
4370
4365B
4354
EO or Mechanically
Rotating Iris
Fig. 1I23A-23B

FIG. 63B

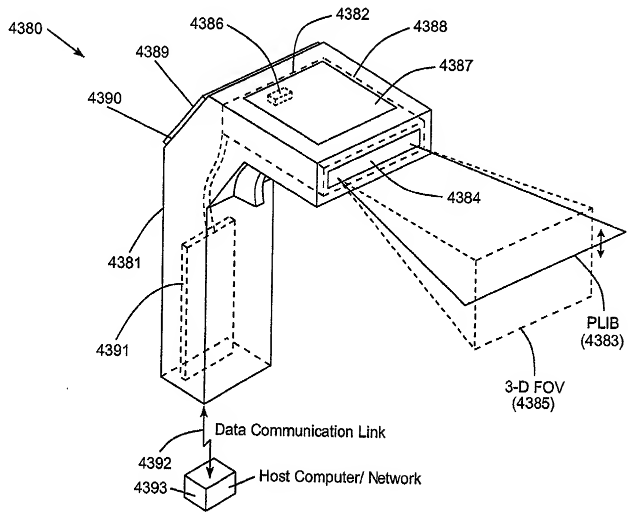
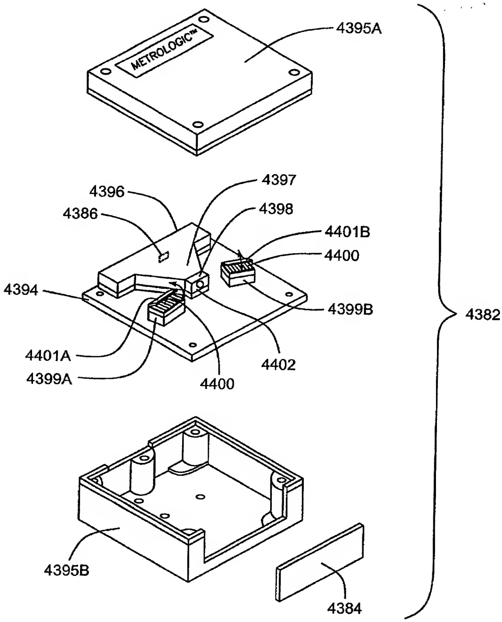

4380
4386
4382
4388
4389
4387
4390
4384
4381
4391
PLIB
(4383)
3-D FOV
(4385)
Data Communication Link
4392
4393
Host Computer/ Network

FIG. 64A



E-optical Shutter
Before IFD Lens
Fig. 1I24A

FIG. 64B

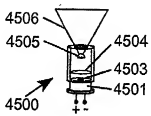


FIG. 65A

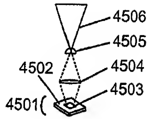


FIG. 65B

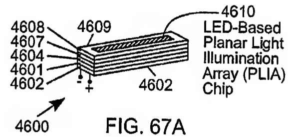


FIG. 67A

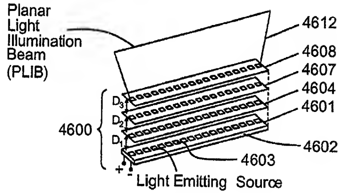


FIG. 67B

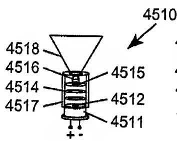


FIG. 66A

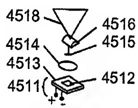


FIG. 66B

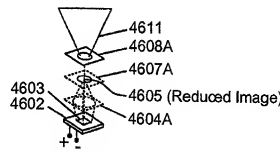


FIG. 67C

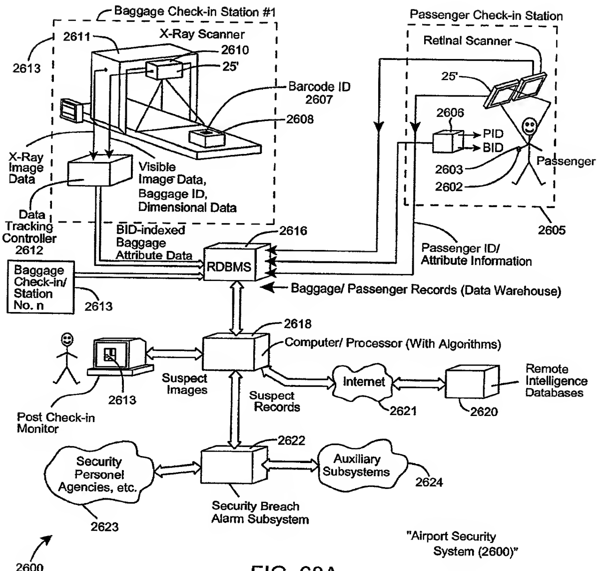


FIG. 68A

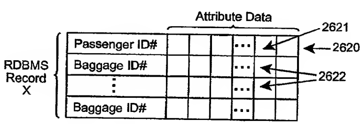


FIG. 68B